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**A PRE-TRANSFER ASSESSMENT FRAMEWORK
FOR
INTERNATIONAL TECHNOLOGY TRANSFER**

by

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in partial fulfilment for the degree of

DOCTOR OF PHILOSOPHY

Department of Mechanical and Marine Engineering
Faculty of Technology

In collaboration with
Rital-CSM Ltd

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ABSTRACT

A PRE-TRANSFER ASSESSMENT FRAMEWORK FOR INTERNATIONAL TECHNOLOGY TRANSFER

Stephen Hobbs

The demands of managing in an international operating environment has changed considerably over the past 20 years due to developments in global markets. Multinational enterprises face fierce international competition and are now tasked not only with developing effective competitive capabilities but also with maximising the knowledge and expertise developed in one part of the organisation by transferring it to another.

This work has investigated the position of multinational enterprises in the developing global market and through a broad and thorough review of current literature, identified a gap in the knowledge – a tool for helping the assessment of the transfer of technology, prior to the transfer process taking place.

Using existing models as a foundation, a new framework has been developed with observations from three case study organisations and the incorporation of other relevant literature. To make use of the new framework to practitioners it has been used as the basis of a workbook by which the anticipated difficulties can be judged and a priority focus developed.

Validation of the framework has been carried out by a panel of industrialists and academics experienced in international technology transfer. The thesis concludes with a series of recommendations for further work.

The originality of this work lies in the development by the author of the new pre-transfer assessment framework. This should provide clear advantages over previous approaches and give way to improving the success of technology transfer projects.

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AUTHOR'S DECLARATION

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award.

This research was undertaken whilst the author was employed by Rittal-CSM Ltd., who also financed the research.

Throughout the research regular seminars, conferences and workshops were attended. At some, publications were presented.

Seminars, conferences and workshops:

- Improving Manufacturing Performance in a Distributed Enterprise: Advanced Systems and Tools, Edinburgh, Scotland, 13th and 14th July 1995.
- 28th International Symposium on Automotive Technology and Automation, Stuttgart, Germany, 18th – 22nd September 1995.
- Theory of Constraints in Industry Seminar (Dr Eliyahu Goldratt), Bristol, 27th June 1996.
- Tools and Techniques for Technology Management, The Third Annual Technology Management Symposium, Møller Centre, University of Cambridge, 17th and 18th July 1997.
- International Manufacturing: A Research Symposium, Møller Centre, University of Cambridge, 28th – 30th September 1997.
- International Conference on Strategic Manufacturing, Gleneagles, Scotland, 20th and 21st November 1997.
- Workshop on International Operations, Aston Business School, Aston University Birmingham, 31st March 1998.
- International Technology Transfer Workshop, Downing College, University of Cambridge, 8th March 2001.

Publications:

- Hughes, D. R., Hobbs, S., and Larson, P., "Computer Aids To Distributed Decision Making In The Extended Enterprise", The International Conference On Improving Manufacturing Performance In A Distributed Enterprise: Advanced Systems And Tools, Edinburgh, Scotland, 13 & 14 July 1995.
- Hobbs, S., and Hughes, D. R., "The Strategic Positioning Of World Class Manufacturing Techniques: The Multiplier Effect". 28th International Symposium on Automotive Technology and Automation, Stuttgart Germany, 18 - 22 Sept. 1995.

- Hobbs, S., and Hughes, D. R., "An Analysis Of The Logic Of The Design Of An Engineered Set-Up Reduction", International Journal Of Engineering Applications 98(1), ISBN 0 94 8255 84 6.
- Hobbs, S., Bennett, J. and Burns, R., "A Learning Curve Approach to Reducing the Cost of Technology Transfer in the Context of Multi-Site Manufacturing Operations". European Operations Management Association – Workshop on International Operations, Aston Business School, 31 March 1998.

Signed
Date

CHAPTER ONE INTRODUCTION

The research described in this thesis was carried out part-time, with the University of Plymouth whilst the author was employed by Rittal-CSM Ltd. The research was supported by the Department of Mechanical and Marine Engineering within the Faculty of Technology.

The objectives of this Chapter are to:

- describe the increasing importance of maximising international companies capabilities specifically their own knowledge based technologies.
- present the reasons for carrying out the research.

1.1 Background

As world markets have opened up so has the need for firms to exceed customers' expectations. It is no longer sufficient for manufacturing companies to simply have the market share or operate competitively in it's home country. Indeed, "Firms that come from highly competitive geographical markets have tended to have a better ability to develop competitive capabilities than those from less competitive regions" (Porter, 1990).

In 1997 Jack Welch - chief executive of General Electric, Waters (1997)

gives America's view on global competitiveness:

“The aim in global business is to get the best ideas from everywhere, ... my job is allocating capital, human and financial resources, and transferring best practice.”

The above statement supports the fact that companies which trade in the global market will sooner or later have to consider manufacturing their products globally if they do not already do so. Both those companies which already manufacture globally, and those which will have to in the future, will also need to maximise already proven technologies and best practices.

Within their survey of global manufacturing, De Meyer et al (1996) sought to identify differences in strategy and performance between US, European and Japanese firms. Whilst they identified a number of general differences, their study demonstrated that the best competitors from the three regions have quite similar capabilities, performances and strengths. In terms of strategy and results, De Meyer et al found that the world competitors that were studied had grown closer to each other and that their response to competition was also similar: exploit continuous improvements, keep investing in quality and spread the risks by internationalising. This closeness of performance of the better firms suggests that specific competencies in a particular region will no longer be sufficient to maintain a competitive advantage.

From the above, it is clear to see that to enable global manufacturers to make best use of their technological knowledge, they will have to transfer it across international boundaries. However, identifying the need to maximise a company's capabilities is one thing, transferring them successfully to other sites throughout the world is something quite different. It is insufficient merely to draw attention to the availability of new techniques in

production. There must, in the first instance be a readiness to put the new techniques promptly and effectively to work. In other words – importing it is one thing, getting the best from it is another (Flynn, 1966). For instance, the development of tacitly embedded competitive capabilities is so tied up to the history of the firm in terms of previous levels of learning, investment and development activities, that these aspects of firm resources are inimitable (Barney, 1991; Dosi et al, 1992). Would-be imitators are faced with the difficulties of discovering and repeating the developmental process and the considerable lag involved in doing so. Unlike the purchase of a physical product, technology transfer requires the investment in learning to handle the technology (Castley, 1996). No technology is applied in a completely ‘given’ form; changes are always necessary to suit local scales, materials, climate, skills and market needs (Lall, 1987).

This thesis will consider the global market and the competitive capabilities a firm needs to maximise if they are to be considered as a serious global player. Following a study of the strategic position of multinational enterprises (MNEs) and the role they play, the thesis will analyse the components of the technology MNEs will be transferring between themselves if they are to maximise their knowledge base by introducing their strategic capabilities throughout their own manufacturing network.

The objective of this research investigation is to develop a framework which will enable those involved with international technology transfer to assess the elements involved with the process and highlight potential problem areas prior to the actual activities taking place. The heart of the research is to not only develop a framework, but to make it usable to practitioners in the form of a workbook.

The development of the framework is based on a foundation of a thorough literature survey considering current thinking on the subject and building on this the findings observed during the case studies made within 3 manufacturing companies:

1. Kital GmbH
2. ALSTOM Power
3. Nissan Motors UK

The new framework was validated by a panel consisting of industrialists, experienced in the field of international technology transfer and academics learned in either international technology or in one of the related fields.

1.1 Need for the research

From 1981 to 1995 the author was involved with international technology transfer – predominantly from the perspective of a practitioner at the host site receiving technologies developed within the German factories within the group. During the many cases over the period, some reported in Chapter 4, the author, highlighted that a pre-transfer evaluation was lacking. Many of the difficulties were encountered and resolved during the implementation stage, but this was always considered to be reactive and costly. Prior knowledge of difficulties encountered would have resulted in different decisions being made and priorities changed. This period of experience was the catalyst for the author's interest in researching into technology transfer.

The effectiveness of international transfer of 'knowledge and best practices' – leveraging existing knowledge through transfer is reported by O'Dell et al (1998). However, the process of technology transfer is not without pitfalls.

Pisano (1996) emphasised the need to pre-empt problems through careful planning, similarly Szulanski (2000) highlights the importance of planning the technology transfer process to minimise 'difficulty' during the implementation stage. Beherman and Wallender (1976) highlighted the importance of the evaluation of the appropriateness of the technology for local needs. Although based on manufacturing mobility, Steele et al (1997) include evaluation as a key activity of their manufacturing transfer framework. Clearly there is a call for an evaluation tool by academics.

Not only have the author and scholarly researchers identified a need for a pre-transfer assessment tool but within the validation panel feedback, all respondents (industrial and academic) confirmed that their previous experiences would have been easier had a pre-transfer tool been available.

Consequently, both experienced researchers and industrialists all confirm that there is without question a clear need for a pre-transfer assessment tool for international technology transfer.

In the context of transferring technologies which are predominantly knowledge based, such as the best practices described by O'Dell et al (1998), where the knowledge is deeply embedded into the personnel of the company, there are no pre-transfer assessment tools available to the practitioner. That is, despite the considerable amount of scholarly research into the transfer of 'know how' in product manufacture, the area of research into the way a 'firm' sees as the best way to produce their product is predominantly untouched.

1.3 Aim and objectives of the research

The aim of the research investigation is to produce a framework to identify the likely issues and difficulties that may be encountered in international technology transfer projects. In order to achieve this aim, the objectives of the research are:

1. To select a suitable research methodology, appropriate for international production operations management.
2. To critically review current literature relating to international technology transfer within MNEs and identify gaps in current knowledge.
3. To undertake and evaluate case studies within three MNEs.
4. To develop and validate a pre-transfer assessment framework.
5. To provide practitioners of technology transfer with a pre-transfer assessment framework which will enable them to judge where probable difficulties lie, before the transfer phase begins.

1.4 Contribution to knowledge - originality

The research critiques current models and frameworks for international technology transfer and highlights the gap in current knowledge – a pre-transfer assessment framework for intra firm use. The technology involved includes:

1. The generic technologies or best practices which a firm uses in a particular way to improve their competitive capabilities.
2. Firm specific ways of producing products which again help their competitive capabilities.

The technologies being investigated are normally 'off the shelf' and readily available to any firm. However, this research concentrates not so much on the technology itself or the successful use on one site – but the transfer of it to another site. The research does not

evaluate the technology for effectiveness nor does it critique if the technology actually is
practical. The research looks specifically at the technologies which the 'firms' considers to
be most effective and the best way of doing a job.

To introduce the framework in a practical and usable way, it will be presented in a
handbook with the elements of the framework leading the practitioner to highlight
potential areas of difficulty.

The author's contribution to knowledge lies in the development of the new framework
which is presented in Chapter 5. In section 5.5 'Formulation of the framework', the work
is original and provides practitioners with a useful tool to aid international technology
transfer. Not only does the new framework include elements not included in previous
models and frameworks, it also incorporates two extra dimensions to the inter-site
environment: the corporate and global environments.

1.5 Case studies

The research was carried out between January 1996 and May 2002, with empirical
evidence being collected by the author through action research within the Rittal
organisation and data collection through semi-structured interviews at 2 further case study
sites, ALSTOM Power and Nissan Motors UK. Interviews were held with senior
managers and follow up investigation at shop floor level was carried out to gain full
understanding of the transfer cases.

1.5.1 The author's position in industry

The author is a chartered mechanical engineer employed by Rittal-CSM¹ as Technical Director and is a member of the Companies Board of Directors. His operational responsibilities include all activities associated with production and engineering:

- Product design and development.
- Manufacture, through to assembly and despatch.
- Production services –
 - Customer support.
 - Production control.
 - Material control.
 - Maintenance
- Process improvement, in terms of quality and throughput.
- Systems development and integration.
- Capital investment.

The site is one of the most technically advanced manufacturing plants in the electrical and electronic enclosure industry with almost 700 employees and a turnover of £80m.

Products produced at the Plymouth plant are enclosures for housing computers (predominantly servers) and data-communication facilities. The enclosures can be floor standing, up to 2.3 metres high, or wall mounted depending upon the volume of electronics to be housed or the environment within which the equipment is to be sited (factory or office). They can protect the equipment inside against various external affects such as earthquake dynamic loading or 'radio frequency interference' (RFI) for instance. Additionally, the design of the product can either allow air cooling through ventilated

¹ Rittal-CSM are part of the German owned group 'Rittal GmbH' (see section 1.5.2)

and roofs or protect the equipment against the local environment such as dust or rain. The enclosures are normally manufactured from sheet steel which follows a generic sequence of: piercing, folding, welding, grinding, painting and assembly.

Amongst many others, major customers include Compaq (see Figure 1-1), Dell, Sun Microsystems, Ericsson and Motorola.

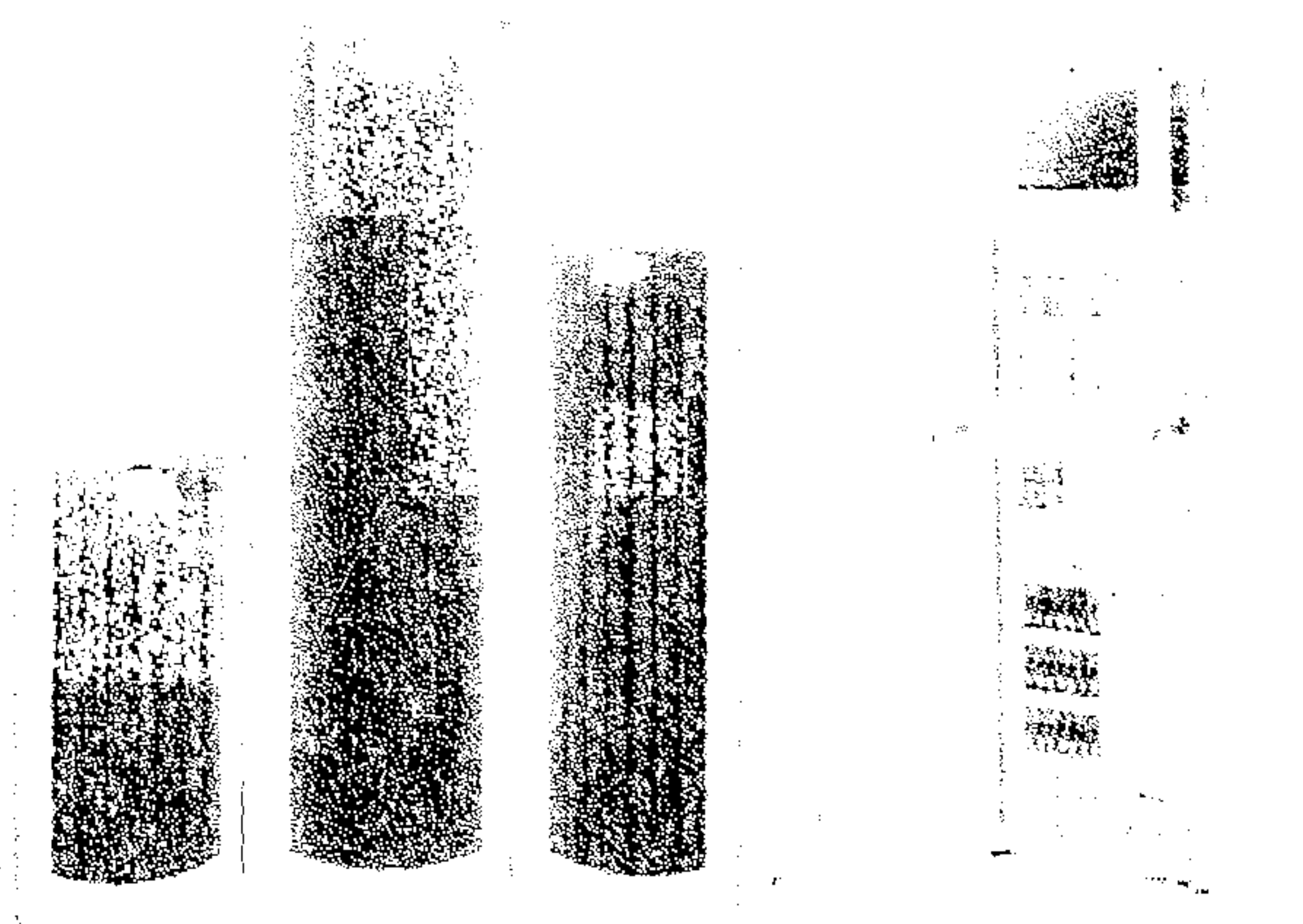


Figure 1-1 Server cabinets for Compaq Computer Corporation, produced at Kilmac-CSM

In addition to the operational responsibilities at the Plymouth site, the author's responsibilities also include competitive capability development at the company's Indian manufacturing facility. Furthermore, he is deeply involved in the transfer of technology between the German and US sites within the group.

International responsibilities obviously necessitate global travel enabling first hand experience of observing and carrying out the many activities of international technology transfer including that of the sender, transferor and receiver. Observing and experiencing the perspective of the home and host.

The authors position in industry has provided a particularly fortunate aspect to the research whereby the author not only has access to senior personnel within the case study organisations but also the wherewithal within Rittal to become involved with technology transfers as and when he considers necessary.

The principal test site in this research is Rittal-CSM in Plymouth, the company which the author is employed by, is part of a large international organisation 'Rittal GmbH' a German owned group. The company's headquarters is in Herborn, some 80km north of Frankfurt. In addition to the research and design activities being centred here, international sales and marketing activities also take place at Herborn. The total workforce of the group globally is in excess of 8500.

The main products for the group are electronic and electrical enclosures, predominantly used for industrial and office based installations. Typical applications for the electrical enclosures are control cabinets for machine tools, either floor standing or wall mounted, which house the switchgear. These cabinets are designed to withstand industrial and outdoor environments. The electronic cabinets, however, are designed to house data-communication and computer control systems – mostly servers. These are normally designed for office or computer centre environments.

Additionally, the company produce many additional accessories such as air conditioning units for the cabinets and bus-bar systems. In total there are more than 8000 standard products.

1.5.2.2 Manufacturing

In addition to the 7 factories in Germany, there are also 1 in UK, 3 in USA, 1 in India, 1 in Italy, 1 in Canada, 1 in Australia, 1 in China and 2 in France. One of the main manufacturing strategies is to design products which are difficult to imitate. That is, the basic frame structure of the cabinets are normally extremely sophisticated necessitating complex high-tech (and consequently expensive) machinery which prevent all but the very largest competitors from imitating the performance of the product. The introduction of a major new product can typically cost in excess of DM 100m. Specialist machinery will almost always include roll-form lines (up to 30 stages and most recently including in-line laser welding), power presses (up to 630 Tonnes), robot welding cells (10 welding robots using MIG and plasma powder processes), etc.

The production technologies developed within the German factories are usually transferred to the international factories after most of the debugging has been completed. This is not just the case where products which are near to end of their life cycle in Europe being transferred to India but the introduction of new products.

1.5.2.3 International sales

Rittal have daughter sales companies in 34 different countries with distribution centres in a further 26 countries.

1.5.2.4 Difficulties of international technology transfer within the Rittal organisation

During the process of transferring technologies between the international sites, many difficulties were identified. Primarily, transfer experiences were between the German factories, (home sites) to the USA and UK factories (host sites) and later to the Indian

transfer. The transfer method was usually an individual or small team who would visit the host site and explain the way a technology worked at the home site and tell/persuade the host site how to adopt the technology.

Although not exhaustive, some of the difficulties encountered are listed below:

◆ Initiator of the technology transfer.

Sometimes the proposal was from head office with little consultation with the host site.

◆ Cultural effects.

German/American; German/British; German/Indian.

◆ Willingness to receive.

Co-operation of personnel at the host site.

◆ Frustration of the transferor.

Encountering problems which could have been foreseen and solutions prepared.

◆ Full understanding of the technology from both the home and host perspective.

Insufficient knowledge to transfer the technology effectively, limited ability to learn the level of knowledge being transferred.

◆ Resources to adopt the technology.

Personnel too busy doing their own jobs to be freed up for training.

Difficulties experienced during transfers where the author was personally involved highlighted to him the need that a formal process was needed, particularly in the pre-transfer stage where those involved could predict the likely difficulties they were about to encounter.

1.5.3 ALSTOM Power.

Known as GEC Alstom until March 1999 when ABB bought a 50% share in the company held by GEC and was called ABB Alstom. The ABB share was then acquired by Alstom in May 2000 and the company was renamed 'ALSTOM Power'.

Globally, the company employ some 54,000 employees, 12% of whom work in the UK, and turnover in excess of €10 billion. ALSTOM Power produce in excess of 20% of the world-wide market share with 12 manufacturing sites in UK, France, Germany and Mexico.

The main products of 'ALSTOM Power' are nuclear and fossil fired power stations, up to 1500MW. However, the host manufacturing site during this research, was at Rugby, where the steam turbines (see Figure 1-2) are produced. The site employ in excess of 900 employees and are the UK headquarters of the power generation division.

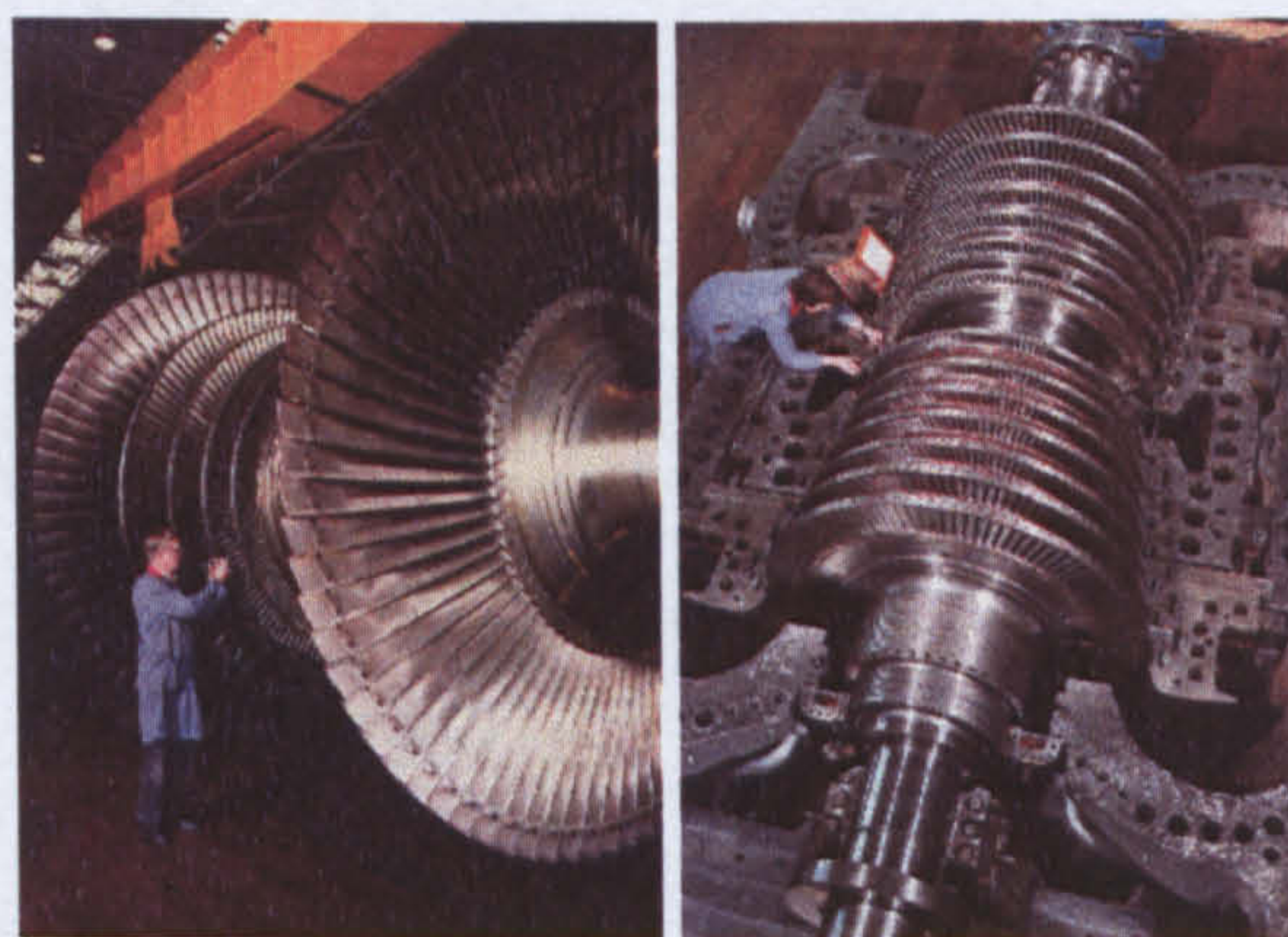


Figure 1-2 Low pressure steam turbine rotor (left) and intermediate pressure cylinder assembly (right) produced at ALSTOM Power

1.5.4 Nissan Motors UK

Manufacturers of motor cars in Sunderland, Tyne and Wear, since March 1999 the Japanese based company have been 50% owned by Renault. The prime host site during this research is Nissan Motors UK in Sunderland where since 1986 the Micra and Primera models have been produced and more recently, the Almera, (Figure 1-3). The site employ 4100 employees and are considered as one of the most efficient car production plants in the world (Fowler, 2000).



Figure 1-3 Production of the Almera motor car at the Sunderland plant

1.6 Structure of the thesis

This section will describe the remaining Chapters of the thesis and outline the content therein.

Chapter 2, Research methodology, reports the methodology employed to investigate the research problem identified in Chapter 3. The Chapter outlines the design of the research methodology, the action research and case studies investigated and validation processes. Concluding with the anticipated quality of information and credibility of solution.

Chapter 3, Literature review, reviews the literature relating to the role of multinational enterprises (MNEs) in global competitiveness. It goes on to review the competitive capabilities of MNEs in the global market and the processes of technology transfer. Current technology transfer models and frameworks are reviewed and critiqued. The

literature review concludes with the identification of the absence of an accepted method for pre-transfer assessment for technology.

Chapter 4, Case studies, gives a detailed review of the action research and case studies. The action research is carried out within the Rittal organisation, reviewing technology transfers between manufacturing sites in UK, Germany, USA and India.

The case studies investigated include:

- ALSTOM Power with manufacturing sites in UK, France, Germany and Mexico.
- Nissan Motors UK who transfer technology between themselves and Japan.

Chapter 5, Development of the framework, discusses the development of the framework. It covers the descriptive phase of the research cycle by bringing together the existing models from the literature review and then integrating the findings from the action research and case studies, see Figure 1-4. The proposed new framework will be presented and its practical use within a workbook for re-transfer assessment.

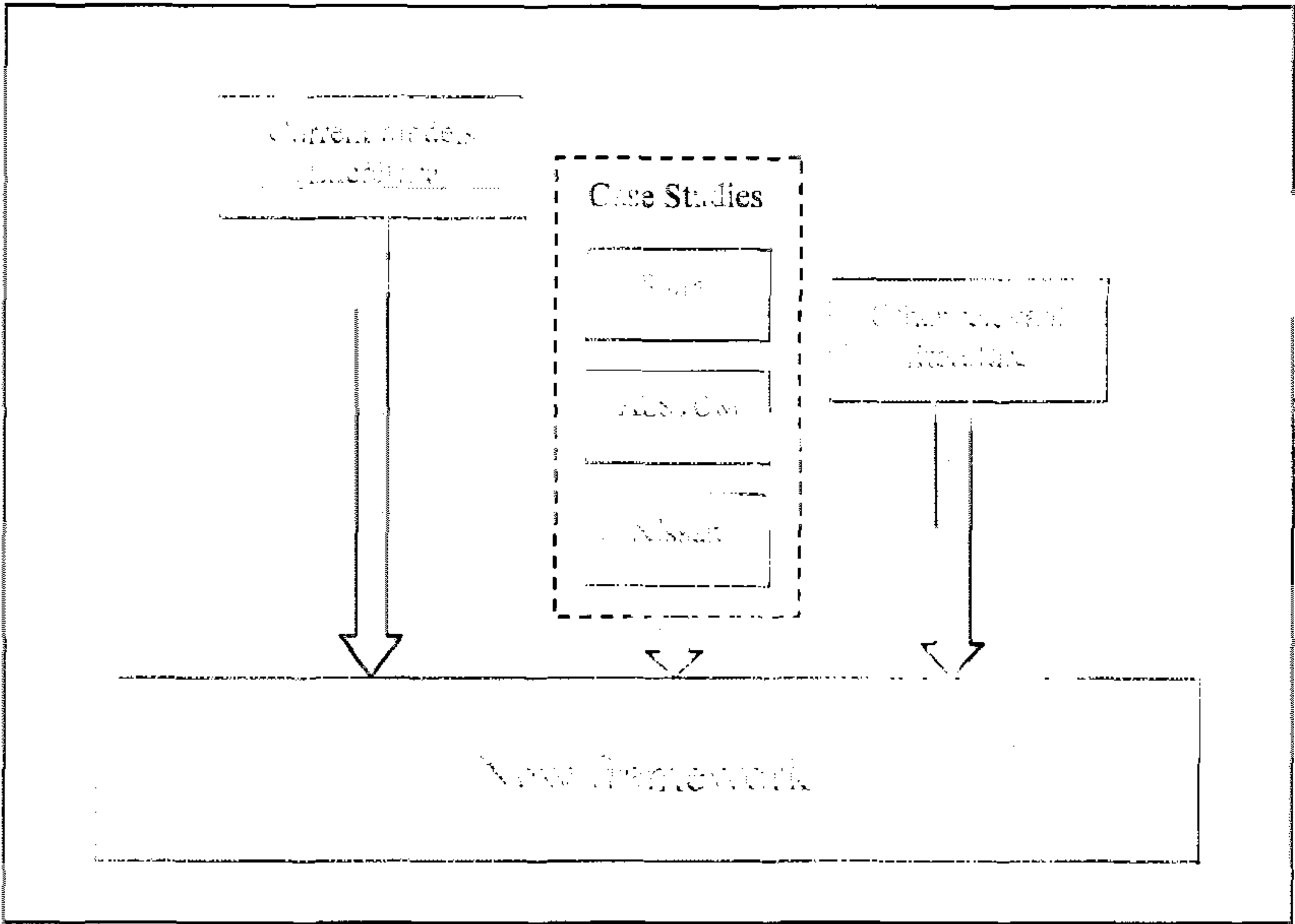


Figure 1-4 Representation of the development of the framework

Chapter 6, *Validation/testing phase of the research*, deals with the evaluation and testing phase of the research cycle. The Chapter covers the continuous research cycle by reporting the live testing of the framework and the consequent changes and re-testing. It also covers the framework validation by a panel of industrialists and researchers in international technology transfer. Chapter 6 concludes with an analysis of the remarks and arguments from the panel.

Chapter 7, *Discussion and conclusions*, will discuss the findings of the research – shortcomings of the research methodology, comments from the validation panel and recommendations for future work.

1.7 Summary

This Chapter has outlined the scope of the research, summarising the research methodology, case study sites, development process, method of validation and explanation of the author's contribution to knowledge.

The following Chapter will define the research methodology adopted and outline the working approach.

CHAPTER TWO RESEARCH METHODOLOGY

The previous Chapter has established the reasons for undertaking the research and stated the principal aim and objectives. The objective of this Chapter is to describe the research methodology. Building on the needs of the practitioner, the philosophical position is justified. Current research methods are evaluated and tools of data collection are presented.

2.1 Introduction

The primary aim of the research is to develop a useful and practical solution which will help decision makers to predict the probable difficulties which would be encountered during the transfer of technology between different manufacturing sites of global manufacturing enterprises. In identifying an appropriate research methodology, emphasis is placed on how managers may benefit from the use of the developed framework.

Manufacturing is by definition an integral part of the production operation and by virtue of the fact that technology affects the procedures and processes, it is therefore the concern of operations management (Voss, 1984). This reasoning forms the basis for the philosophical position of the research.

There has been ongoing debate about the most appropriate philosophical position from which a method should be derived (Meredith et al, 1989; Buffa, 1980; Chase, 1980; Susman & Evered, 1978). There are two main traditions:

1. Positivism. Observations can be measured objectively and uses quantitative methods.
2. Interpretivism. Inferred from the meanings that people place upon their experiences.

Wasthby-Smith et al (1991) argue "... when it comes to the use of quantitative or qualitative methods and to the issues of research design, the difference breaks down", suggesting that in many areas, the two overlap. However, they go on to suggest that interpretivistic methods, such as in-depth longitudinal case studies are appropriate for understanding processes such as international technology transfer.

Meredith et al (1989) conclude that the type of research methods suitable for operational management or more interrelated, more situation – or people-dependent topics in operations require the additional perspective afforded through the natural and existential methodologies. The term "natural" refers to the method of data collection from direct observation, and "existential" refers to research methods where each observer may have a different interpretation of the direct observations made. Research methods categorised in Meredith et al's work as "natural" include both Action Research and Case Studies.

Qualitative case studies are however, an inevitably subjective means of capturing data. The researcher creates his or her own classification and guideposts, decides what to look at and what to ignore, what to record and what not, and so on (Kaplan 1986). Additionally, the units of analysis are process activities, measured as fixed entities, the attributes of which can vary along scales such as from high to low, etc. Van de Ven (1992).

2.3 Needs of the practitioner

Section 2.1 has shown that the research lays in the field of production operations management (POM) (Voss, 1984). Within the scope of POM, Thomas and Tymon (1982) use the “needs of the practitioner” as the focus to assess the success of a research project. The practitioner being: “any line manager, staff specialist, consultant or any other organisation actor”.

Using the practitioner as a point of reference, Thomas and Tymon (1982) propose a framework that identifies the ‘needs’ of the practitioner and suggest 5 key needs that should be fulfilled by the new knowledge: descriptive relevance, goal relevance, operational validity, non-obviousness and timeliness. The effectiveness of this research or successful contribution to knowledge will be assessed through the usefulness to the practitioners.

It is therefore appropriate at this stage to consider what is behind each of the needs:

- *Descriptive relevance* – refers to how accurately the findings of the research project have succeeded in capturing the problem or phenomena encountered by the practitioner. It is concerned with how general or specific the new knowledge is, by questioning whether it is relevant to any practitioner with a specific type of

organisational problem. It can also be described as the external validity of the research findings (Campbell and Stanley, 1965). To measure descriptive relevance, the researcher must consider how general the contribution to knowledge is.

- *Goal relevance* – is concerned with the relevance of results gained from the practitioners applying the new knowledge. The practitioner has an objective to change or influence a problem or phenomenon within the company, the new knowledge should help the practitioner to meet this objective.
- *Operational validity* – is concerned with how easy it is for the practitioner to carry out the actions required to use the new knowledge.
- *Non-obviousness* – refers to the degree by which the new knowledge resulting from the research work is not obvious to the practitioner or part of “common sense” that is already used by the practitioner.
- *Timeliness* – is a measure of whether the new knowledge is available to be used by the practitioner when required.

Aside of the content of the new knowledge, the 5 key needs described above should be met. The output of the research should therefore:

- be useful to practitioners of international technology transfer (descriptive relevance).
- help practitioners of international technology transfer reach their objectives, that is, to identify difficulties prior to the commencement of the transfer process (goal relevance).
- be straightforward and easy to use (operational validity).
- be more than simple common sense (non-obviousness).
- be available at a point in time when the practitioner needs to use the pre-assessment tool (timeliness).

The focus of the research is on the usefulness of a pre-transfer assessment framework.

2.1 Research cycle

Several authors have proposed learning cycles within an operations management environment. Although not specifically directed towards operations management, Handy (1998) suggests that learning consists of four main stages:

1. Questioning
2. Conceptualisation
3. Experimentation
4. Consolidation

The experiential model of learning presented by Kolb et al (1979) is shown in Figure 2-1, who suggest that people learn best about work at work, by applying experience with new found knowledge.

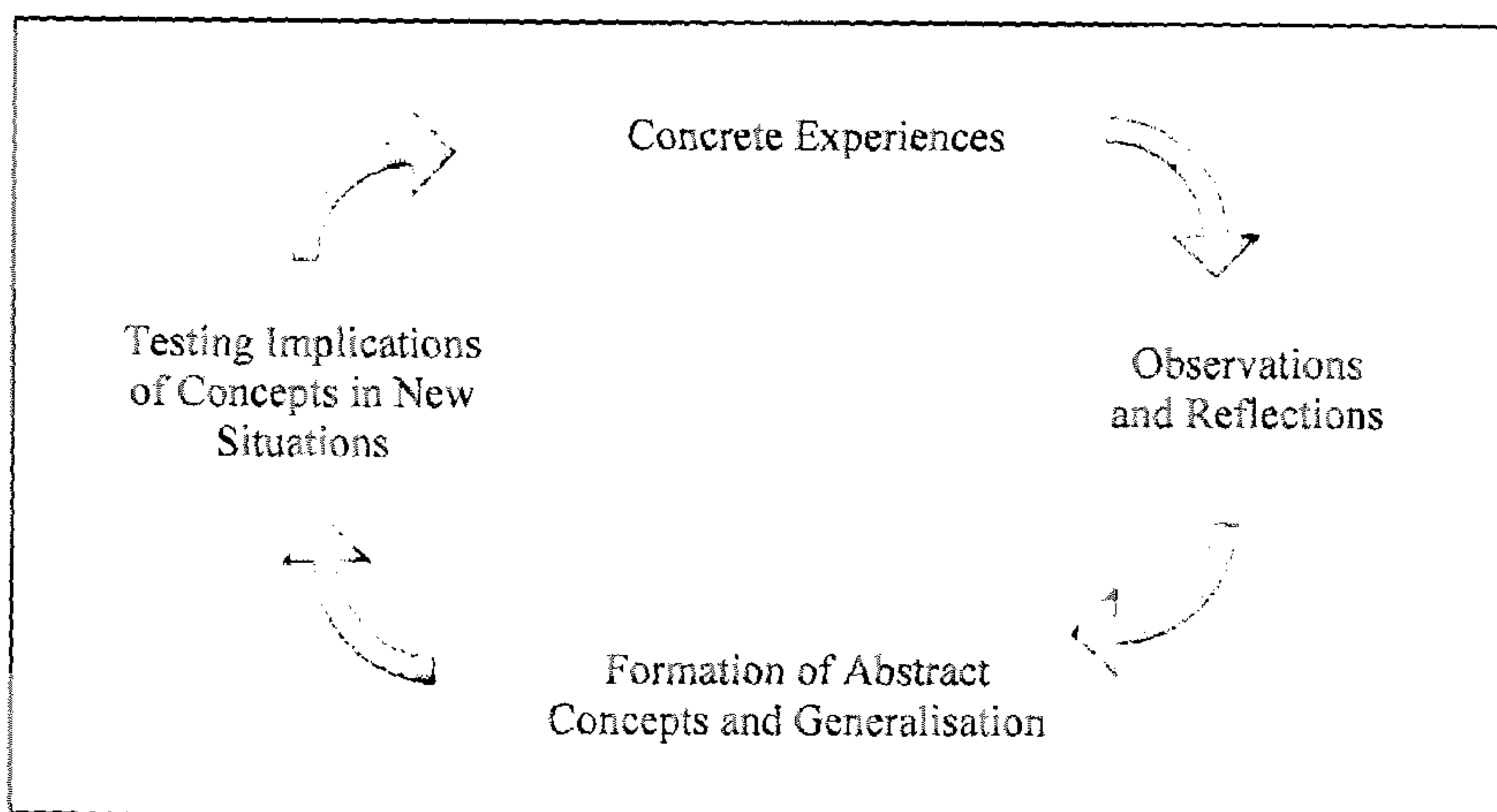


Figure 2-1 Experiential Learning Cycle - Kolb et al (1979)

However, Meredith et al (1989) suggest that research into operational management generally involves a continuous cycle of: "Description, Explanation and Testing" which they call the "Research cycle", shown in Figure 2-2.

Research phase – where activities are undertaken to gain experience of the phenomenon under study, to capture information about the phenomenon, its nature and context. Consider previous concepts that have been used to describe and understand the phenomenon.

Explanation phase – refers to the attempts to understand and explain observations by simplifying or developing abstract concepts and then attempting to extend the concepts to other instances of the phenomenon. The result of this phase is new knowledge which then has to be tested.

Testing phase – tests the new knowledge developed during the previous two phases to determine to what extent the objectives of the concepts are met. The experience gained from the testing phase results in the cycle starting again.

When considering the learning cycles described above it is noticeable that they are not really that different from each other. Perhaps not surprisingly, the learning cycles described above all follow the continuous improvement (or continuous learning) cycle presented by Deming (1986): “Plan, Do, Check Act”.

Superimposed onto Meredith et al’s research cycle are the activities carried out during this research:

Description – Literature review, action research and case studies.

Explanation – Data analysis and formulation of the framework.

Testing – Validation by an academic and industrial panel.

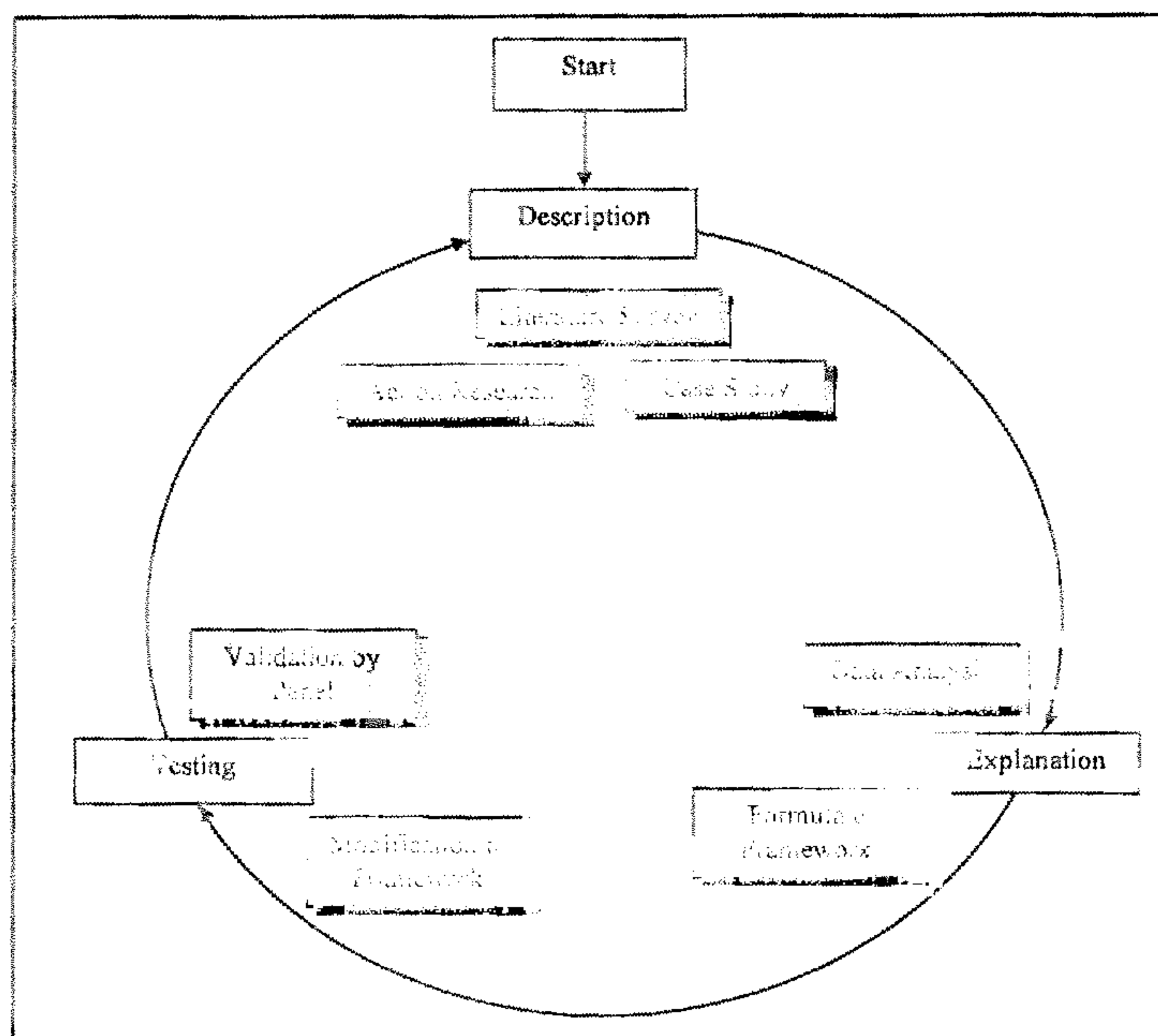


Figure 2-2 Research Cycle - Meredith et al (1989)

Following the research cycle proposed by Meredith et al (1989), Meredith (1992) expands the steps through the description, explanation and testing stages to develop models, frameworks and on to theory (Figure 2-3), emphasising the importance of the complete cycle if the research is to be meaningful towards building theory. Without the full research cycle, Meredith warns of the shortcomings of short circuiting the cycle – that is, the research becomes less realistic and the results become less relevant to operational managers.

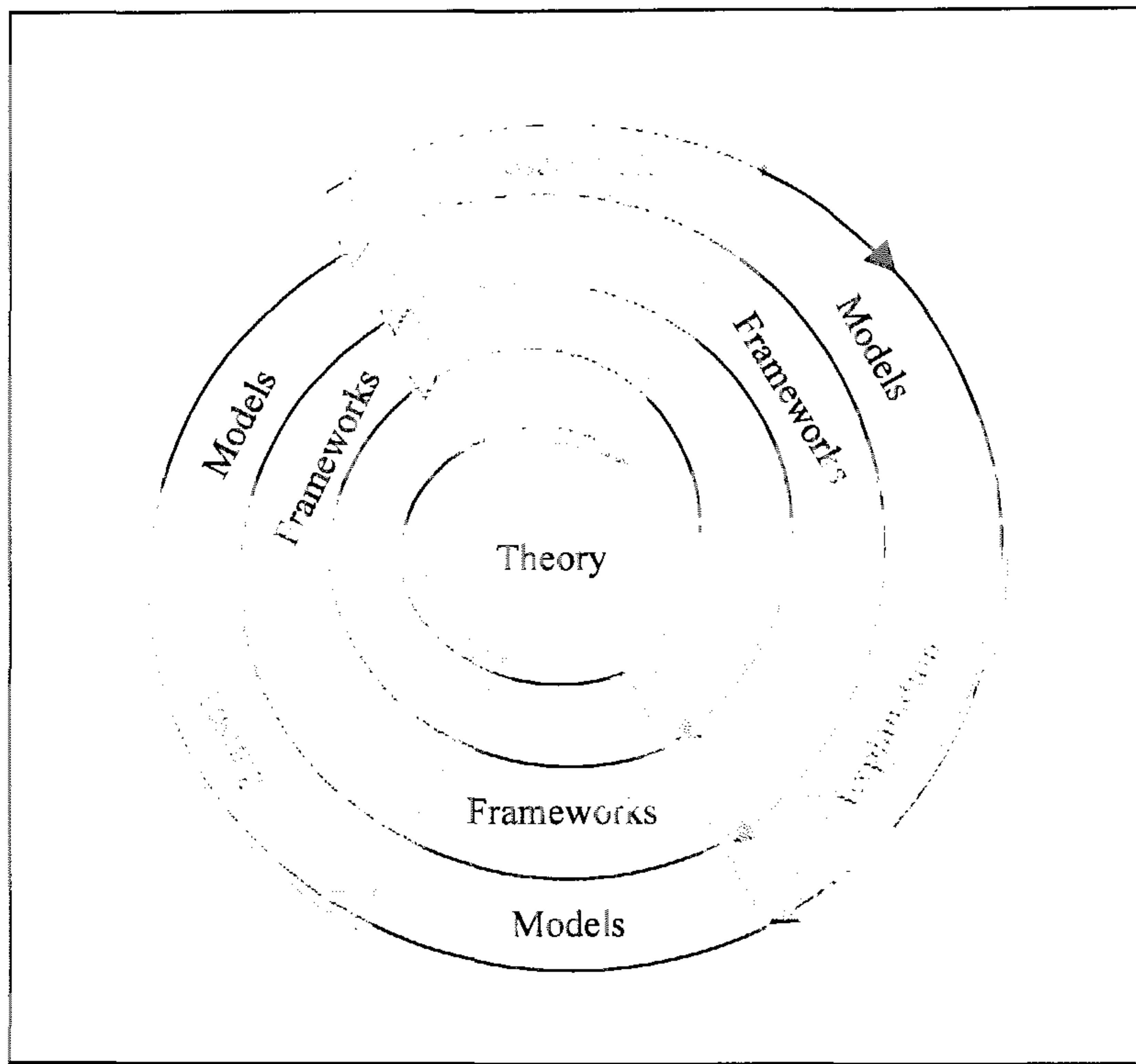


Figure 2-3 The Normal Research Cycle - Meredith (1992)

2.5 Framework

Although many authors use simple models to represent the basic activities in technology transfer (Reddy and Zhao, 1990; Keller and Chinta, 1990; Tsang, 1994; Mansfield, 1974; Ounjian and Carne, 1987; Teece, 1981a), and to some extent Samli (1985), who in a more complex way, proposes a “general model of technology transfer” to explain the processes. However, the authors who present a finer detailed approach use frameworks – having more explanatory power (Steele et al, 1997; Behrman and Wallender, 1976). Miles and Huberman (1984) propose that frameworks offer a graphical representation which allows the researcher to work with all the information at once and to identify interrelationships. This notion is supported by Meredith (1992) who differentiates between conceptual frameworks and models by the “explanatory power”. A framework would encompass many variables and seek to capture much of the complexity of technology transfer. It would identify the relevant variables and the questions which the user must answer in order

to develop conclusions. By contrast, models are situation specific, rigorous and of limited complexity.

3.5 Data collection

Having decided upon the philosophical stance on which the research should be built, and the research cycle to follow, the methods of data collection are considered.

Operations management lies in Meredith et al's (1989) interpretative element of the existential axis of their generic research framework and, due to the fact that the author has direct involvement with the subject, direct observations can be made. In Meredith et al's framework for research methods, the above criteria suggest that the subject is best researched by action research and/or case studies. This approach is also promoted by Warmington (1983) who supports the direct collaboration between the researcher and the practitioner, and by Susman and Evered (1978) who support the generation of theory grounded in action. The combination of few real-time longitudinal cases with many retrospective case studies about the same phenomenon has been coined the dual methodology (Leonard-Barton, 1990). Strengths in each method compensate for weaknesses in the other. Additionally, Chapter 3 will go on to suggest that knowledge would play a significant role in technology transfer. Knowledge is part of a complex human system and can remain tacit and unmeasurable. Consequentially, it is preferable to adopt an interpretiveist stance rather than a positivistic reductionist stance (Adler, 1989). For example, Kogut (1988) recommends case study type research over aggregated statistical analysis of industry data to observe the effects of knowledge transfer motivation on joint venture formation.

Regarding the number of studies, Eisenhardt (1989) suggests that with fewer than 4 cases², it is often difficult to generate theory with much complexity, and its empirical grounding is likely to be unconvincing.

Consequently, the literature above supports that the data collection in this research follows three major approaches:

1. *Literature review.* A thorough critique of the literature associated with international technology transfer, see Chapter 3.
2. *Action research.* Within Rittal-CSM. The company in which the author is employed.
3. *Case studies.* Within the following companies –
 - Rittal: Werk (Germany); Corporation (USA); India.
 - ALSTOM Power.
 - Nissan Motors UK.

The combination of in depth longitudinal studies observed in action research and multiple-site retrospective studies observed during the case studies offers a broad foundation on which to base the solution of the research.

Table 2-1 summarises the international content of the research within Rittal, ALSTOM Power and Nissan:

² Whilst this research programme has investigated only 3 companies, the content involves some 9 sites spread globally and therefore meets Eisenhardt's (1989) criteria for a useful number of case studies.

Company	International Partners	Comments
Rittal-CSM	UK – India UK – USA	Academic Research
Rittal Werk	Germany – UK Germany – India Germany – USA	Case Studies
ALSTOM Power	UK – France UK – Germany France – UK France – Germany	
NISSAN MOTORS UK	UK – Japan Japan – UK	

Table 2-1 International content of the research

2.6.1 Case study interviews

The selection of interviewee was based primarily on their knowledge and experience of international technology transfer and the fact that they were senior managers within their companies. This gave a level of validity to the comments made during interview. Additionally, each of the managers were known personally to the author which consequently enabled relaxed discussions whereby a high level of honesty was inevitable.

Although the interviews with representatives from the case study sites were initially semi-structured, the interviews were allowed to also cover neighbouring subjects for 2 reasons:

1. To see if there was interesting relevant data which the interviewee had not considered as being relevant – adding a richness to the data.
2. To gain information/ideas which could be used within Rittal-CSM to improve performance.

Questions with obvious answers were not asked, to avoid frustration from the interviewee.

The structure of interview was as follows:

1. Introduction/background to the research.

This was to ensure that the interviewee understood the area of interest, particularly in relation to the technology being investigated.

2. How does the company transfer technologies? What is the mechanism for initiating a project?

Aimed at understanding the way the companies transfer technology.

3. Examples of technology transfers, with particular reference to the difficulties encountered.

General data collection to understand the sequence of events and to record the difficulties and issues reported.

4. Are technologies transferred in both directions, that is, to and from other sites?

To prompt discussion about the firm's experiences as a home and host site.

2.7 Action research

Action research is where research is carried out through being involved with the phenomenon under study (Meredith et al, 1989). Action research is social research that is explicitly concerned to develop findings that can be applied in organisations. It is necessarily collaborative because it involves working with members of an organisation on a specific problem (Bryman 1989), and contributes to a generalised understanding of the situation, and thereby, to the goals of social science (Rapport, 1970). Action research begins by advocating "... a framework ... for dealing with reality" (Susman 1983).

2.7.1 The authors position within the action research

The action research was carried out within the company in which the author is employed, Rittal-CSM. As explained earlier, the author is employed as Technical Director at the

Plymouth site, and also has responsibilities at the company's Indian manufacturing plant. Additionally, he is deeply involved in the transfer of technology between the German and U.S sites within the group.

During some 12 visits to the Indian factory, 7 to the USA plants and 15 to the German factories, the author was fully engaged in the transfer of technology between the international sites. This involved:

- Observing technologies in practice.
- Recording whatever was possible regarding the technology in practice. This included sketches, photographs and video recording.
- Discussed the nuances and idiosyncrasies with the home engineers.
- Collected drawings, specifications, available documentation (which was rare).
- Expenditure and declared savings.

The experiences the author gained through being involved with the technology transfers described above, gave the author a thorough understanding of the process of technology transfer within the Rittal group and consequently an excellent platform to observe other case study sites. There were two other benefits for the author in the context of this research:

1. The experience enabled a real understanding of the published literature on the subject.
2. The author was able to carry out 'trial runs' of the framework as it was being developed.

The direct involvement with technology transfer which the author has, satisfies Meredith et al's (1989) requirement of direct involvement for qualitative observation.

2.8 Case studies

A case study is a history of past or present phenomena, drawn from multiple sources of evidence including interview, observation and documentation. Case studies are where researchers investigate a specific phenomenon through in-depth limited scope study (Meredith et al, 1989). The rich qualitative data a case study can yield provides a good understanding of the dynamics underlying a relationship or problem - “why” the events observed happened (Eisenhardt, 1989; Parkhe, 1993).

The case studies were investigated not only within the German, US and Indian factories of the Rittal group, but also within ALSTOM Power and Nissan Motors UK. Resulting in a balance of real-time longitudinal study, carried out within the action research, coupled with the retrospective case studies supporting Leonard-Barton’s (1990) dual methodology approach of research into case studies.

The principle method of data collection throughout the case studies was by semi-structured interview. Senior managers were chosen for interview where their knowledge, experience and involvement with international technology transfer was high. Interviews were carried out face to face and notes were taken rather than using a tape recorder, this was to help set the interviewees at ease encouraging free talking without the concern that something may be held against them later. Initial interviews lasted a minimum of 1 hour and in most cases, follow up interviews were conducted at the interviewees own manufacturing site, along with telephone calls later to clarify aspects which were not apparent at the time of interview.

2.9 Validation of the framework

Following the development of the framework from the literature review, action research and case studies it was necessary to test it's validity, the 'testing' phase of Meredith et al's research cycle (1989).

To enable the framework to be tested in a live environment, it was used as the foundation of a workbook, see section 5.6. The workbook, a pre-transfer assessment tool would be used to build a representation of the difficulties which are likely to be encountered during the technology transfer. This approach is to put the framework in a practical position whereby both the workbook and framework could be assessed – validation by use, or what Thomas and Tymon (1982) refer to "operational validity". The method of validation was to present the workbook to a panel of academics and industrialists involved in international technology transfer, the results of their comments can be seen in section 6.4.

The case study sites being investigated are all global manufacturing companies with sites in many different countries. Within their own field, all are recognised as being extremely competent companies. Consequently, it was anticipated that the quality of information should be high thus helping towards a sound and credible solution

2.10 Summary

This Chapter has outlined the methodology adopted in this research. The interpretivistic philosophical position was reasoned to be most suitable approach to research into international technology transfer, recognising the shortcomings of direct involvement. The structure of the methodology has been based on Meredith et al's (1989) three-phase research cycle. The description phase will include a thorough literature review which will act as a foundation for the framework to be built on. Additionally, information collected

from the action research and case studies will be included. Finally, the method of validation has been described. That is, validation of the framework being by it's use in a workbook which can be used to assess the difficulties which are likely to be encountered during the actual transfer process.

The following Chapter will review the current literature relating to international technology transfer. It will initially consider the role of MNEs in the global competitive environment along with their competitive capabilities. The Chapter will then analyse in detail, the high knowledge content of the technologies being considered and conclude with a review of the models and frameworks already proposed by other authors.

CHAPTER THREE LITERATURE REVIEW

3.1 Introduction

This Chapter of the thesis will develop a theoretical foundation on which to base the research.

The review of current literature will begin with an appreciation of the global market and focus through the strategic issues facing the global competitor to the gap in current knowledge. A graphical representation of the formulation of the research problem is presented in Figure 3-1.

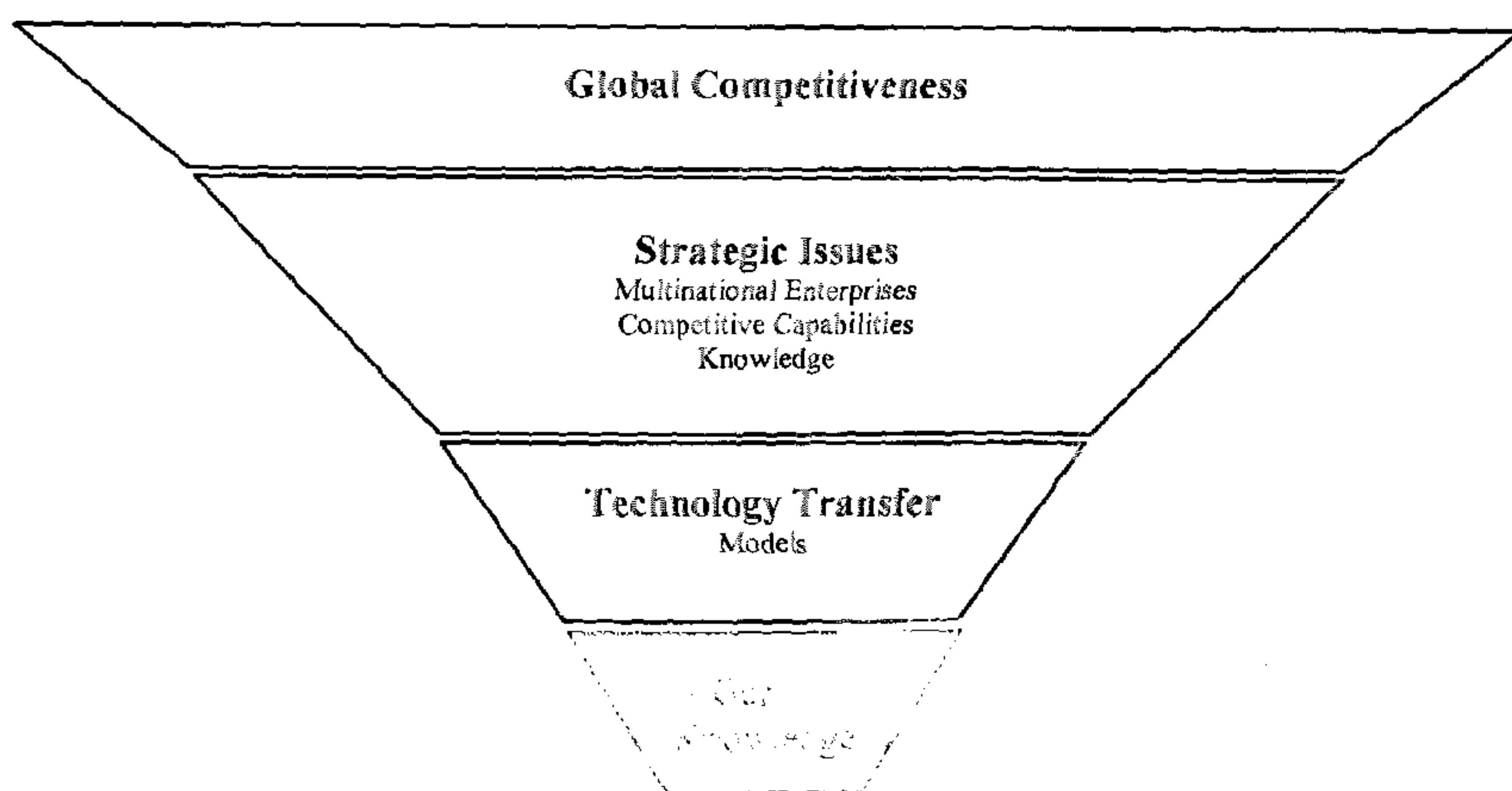


Figure 3-1 Graphical Representation of the research focus

3.2 Global competitiveness

Prior to the first world war, Great Britain was the world's leading technological nation and the era was characterised by the attempts of less advanced nations, particularly European countries and the USA, to close the technology gap (Jeremy, 1992). However, as these

countries developed their technological competencies their competitiveness increased accordingly. This aspect was typified by the automotive industry during the first half of the last century by both Europe and USA (Womack et al. 1990).

During these periods companies were increasingly expanding into new markets world wide, opening new factories. This trend has continued, Ferdows (1997) reports that from 1970 to 1991 world exports doubled and the value of those exports increased by a factor of three. Additionally, of the estimated 37,000 companies around the world which have foreign affiliates, almost 60% are in manufacturing. Examining the same period as Ferdows, Flaherty (1996) reports that, foreign direct investment increased by a factor of 9.4. These are undeniable statistics which substantiate the importance of global competitiveness.

Many companies, particularly in the computer industry (such as Compaq, Dell, IBM and Sun Microsystems³), attack the global market very aggressively and insist on global capabilities as a vendor requirement or, as Hill (1985) would describe as an “order qualifier”. The importance of global manufacturing and distribution capabilities cannot be over emphasised in this industry, as the computer giants will simply not consider a vendor without it. The main reason for their insistence is due to unnecessary costs. Data from the action research show that within the server market, around 50% of all rack enclosures are sold in USA, 30% in Europe, and the rest distributed throughout the rest of the world. Inter-content transportation costs are high and are seen as nonessential, ultimately risking market share.

³ These companies have been identified during the action research.

A critical factor for success in the global market is the ability of a firm to exploit its ownership of monopolistic advantages embodied in the firm's specificities (Lall and Streeten, 1977). Values of this kind are steeped in tacit knowledge, Nonaka and Takeuchi (1995), which is complex, unstructured, knowledge that resides in the heads of individuals and groups, Gupta and Govindarajan (2000). Such learning cannot be easily bought, it must therefore accumulate within the organisation in which it will be exploited (Dierickx and Cool, 1989).

This section has shown from both historical data and current practice, that firms who intend to supply in global industries in the future *will have* global manufacturing capabilities or they *will not* supply. Hindering their chances of success is the fact that on a global basis, they will have to perform at their best in all regions, maximising 'hard to capture' knowledge assets.

3.3 Strategic issues

Skinner (1968) was one of the first strategists to include the manufacturing function in international business strategy and this work has often been developed, see (Hays and Wheelwright (1984), Skinner (1985), Hill (1985)).

For various reasons, many companies have chosen to set-up manufacturing sites in geographically strategic locations around the world, the five categories of motivation to manufacture overseas presented by Ferdows (1989) are:

1. Access to low cost production input factors.
2. Proximity to market.
3. Use of local technological resources.

4. Control and amortisation of technological assets.
5. Pre-emption of competition.

Similarly, Womack et al (1990) in their analysis of the motor industry summarise the advantages of global enterprising as:

1. Protection from trade barriers and currency shifts.
2. A richer product diversity.
3. Development of sophisticated managers through exposure to different environments.
4. Protection against regional cyclisity.
5. Prevention of competitor defended markets from skimming profits to use in competitive markets elsewhere in the world.
6. The advantage of doing everything in one place near the point of sale.

Although there is common belief that many companies open factories in less-developed countries simply to reduce cost (Schroeder, 1993), Ferdows (1997) points out that such belief is often misfounded due to poor productive efficiency in developing countries.

In some circumstances, usually involving major capital projects such as the construction of power stations in China, a company may be forced under contractual terms to manufacture part of the project locally (within the country). This is often the case for ALSTOM Power and the case study shows, for example, and under these circumstances they are expected to pass on technology as part of the overall contract. That is, the know-how to manufacture significant elements of the power station using the previously developed best

Behrman and Wallender (1976) and Teece (1981b) report that when many companies choose to build a new site they will capitalise on their existing best practices and implement changes where they know deficiencies already exist. Although Behrman and Wallender and Teece report on many case studies in the 1970's and 80's, more recent examples supporting this contention are:

- In addition to Toyota building its car plant at Burnaston, Nissan has built theirs near Sunderland, both benefiting from all of the developments and practices that were created within their own Japanese plants. In both cases the control and initiation of the technology transfer was direct from head office.
- Rittal, has recently introduced under the guidance of the author as part of the action research programme, a manufacturing plant in India using best practices and technologies proven within the group, all controlled from the company headquarters in Germany.

The practice of replicating a proven *template* (Nelson and Winter, 1982) as a strategy of exploitation is reported by March (1991) and further developed by Winter and Szulanski (2000) who go on to suggest that the replicator's profits are only limited by the demand for its products and services. Typically, Winter and Szulanski refer to replication as the "McDonalds approach" where an operation is copied to reproduce a proven formula. This practice is also adopted by companies such as Intel when building new semiconductor plants where the target is to duplicate in every single detail (Iansiti, 1998).

Ferdows' (1989) work on the design of the international production function and Porter's (1990) work on internationalisation based upon the value chain both suggest the centrality

of the manufacturing function, and therein the manufacturing processes to international business strategies. Consequently, research into international manufacturing can be justified by its increasing importance to industry and its increasing dynamism.

3.3.1 Multinational enterprises

Multinational enterprises (MNEs) are the main vehicle for international manufacturing, and as Buckley and Casson (1991) propose – a MNE is an enterprise that owns and controls activities in different countries. MNEs possess strong advantages over market-based international operations due to the reasons outlined in section 3.3. Furthermore, MNEs seek competitive advantage through the exploitation of global economies of scale and arbitraging imperfections in the world's capital, material and labour markets (Katz et al. 1996). MNEs possess intangible assets, such as proprietary knowledge, which provide the host country with many advantages – providing they can be transferred (Kumar 1990).

Birkenshaw & Hood (2001) propose that MNEs have evolved through three phases over the past 50 years, both in terms of their geographic scope and the roles played by their foreign subsidiaries:

Paternalism. In the first half of the twentieth century, the dominant model for MNEs was to innovate in the home country and then roll out new products across the corporate empire.

But as foreign markets for the established MNEs became more sophisticated ... it gradually became apparent that the home country did not have a monopoly on innovation and leading-edge thinking.

Expansionism. In the 1970s and 1980s, many MNEs set up “scanning units” to tap into the ideas coming out of key foreign markets, and they built R&D sites abroad to gain access to scientific communities. Corporate investments of this type were a half-hearted attempt to tap into the ideas and opportunities in foreign markets. There were two major problems:

1. Scanning units and foreign labs were attractive in principle but difficult to manage.
2. By defining certain units as responsible for picking up new ideas, corporate managers were implicitly signalling to all other foreign units that they did not have to bother.

Liberalism. A third model now emerging, takes a more democratic approach to the pursuit of new opportunities. It builds on two major arguments:

1. Useful new business ideas can emerge from anywhere in the world, particularly those parts of the organisation who are in direct contact with customers, suppliers and other external parties.
2. The greater the distance from the centre, the less constrained individuals are by traditions, norms and belief structures of the corporation.

Given that MNEs are the main agents for international manufacturing, their activities will provide the foundation for the author’s research into international technology transfer.

3.3.2 Competitive capabilities

Having established that MNEs have a major part to play in the global market, it is appropriate to ask – “what will they have to do to enable them to be competitive?” It has been shown that in an increasing number of markets, particularly those characterised by global competition, being second ranked is no longer an option (Porter, 1990). Yet to achieve outstanding performance a firm has first to know what it is good at doing and

secondly it has to understand how to stay good at doing it. In short, the firm has to know what its 'core competencies' are. The term, first popularised by Prahalad and Hamel (1990). This is an important facet for this research since the technologies being considered include those competitive capabilities which are developed to make imitation difficult.

The profitable expansion of firms being a process of exploiting existing firm specific capabilities and of developing new ones has been recognised for some time by Penrose (1959) and Teece (1981b), but to get a more workable understanding the author refers to literature that takes a slightly more detailed view.

Leonard-Barton (1992) defines a core capability as "the knowledge set that distinguishes and provides a competitive advantage" and argues that there are four dimensions to a knowledge set: (1) Employee knowledge and skills, (2) Technical systems, (3) Managerial systems and (4) Values & norms. However, in their work on 'Dynamic Capabilities', Teece et al (1997) define these as "the ability of an organisation to learn, adapt, change and renew over time", which "involves search, problem finding and problem solving at the organisation level". Prahalad and Hamel (1990) define core capabilities as "the collective learning in the organisation, especially how to co-ordinate diverse production skills and integrate multiple streams of technologies". Concentrating more on the skill element, Stalk et al (1992) view competitive capabilities as the "skills that can transform a company's key business processes into strategic capabilities, thereby leading to competitive success ... hard-to-imitate organisational capabilities that distinguish a company from its competitors in the eyes of its customers". Similarly, Swink and Hegerty (1998) propose that a firm's competitive capabilities are those which support "... product differentiation".

Hayes and Pisano (1994) suggest that a firm's competitive capabilities lie in "... its ability to do certain things better than your competitors can. Such superior organisational capabilities provide a competitive advantage that is much more sustainable than one based on something you can build or buy".

The theme of knowledge (implicitly tacit in Stalk et al's (1992) definition) being common throughout, competitive capabilities is noted and will be discussed later (section 3.5) in more detail to help understand the important relationships between competitive capabilities, knowledge and technology transfer. Additionally, the view that Stalk et al (1992) have on hard-to-imitate capabilities are in line with one of Porter's (1990) generic strategies – differentiation.

3.4 Technology

The previous section has shown the necessity for MNEs to maximise their competitiveness in the global market. This section will demonstrate how technology is a critical component of global competitiveness and break down the elements of technology.

As reported earlier, both Penrose (1959) and Teece (1981b) promote that the profitable expansion of firms is both a process of exploiting existing firm specific capabilities and of developing new ones. Therefore, the technologies considered in this thesis are those which are firm specific in their application, that is, technologies embedded in the processes, products and personnel. It does not concern itself with whether the technology is 'best' or most suitable. Many authors have proposed "fix-all" solutions to manufacture, and equally as many have criticised the solutions pointing out limitations and failure rates of best practices such as TQM, JIT and BPR (Brown 1994; Ramarapa 1995; Tippet and Waits 1994). Confirming the many complexities which operations face in order to compete.

The technologies examined here are the practices which firms use to achieve their competitive competence. Specifically the *way* they produce their products. This could be for instance:

1. The application of generic technologies such as kanban applications, stock control or SMED⁴ theory to set-up reductions.
2. The way in which a product is produced on specific processes, unique to the firm following significant development and expertise. This can be a method where a key market requirement is met in a far more competitive way than the competition can match without excessive investment in machinery and development time.

The list is not exhaustive and is used purely to give the reader an insight into the technologies being investigated. While many authors refer to such technologies as ‘best practices’ (Winter and Szulanski, 2000; O’Dell et al, 1998), there is ongoing debate not only over what a best practice is (Hughes and Smart, 1994), but what the term actually means (Trought, 2000). Within this research the technologies listed above could not really be seen as ‘best practices’ in the sense of thematic models of world class manufacturing or lean production as critiqued by Smart (1996). Nevertheless, this research considers the *way* in which a company finds a practice to work well and is therefore a preferred method to them. Consequently, due to the fact that this thesis does not concern itself with the philosophical debate over terminology, the author will refer to these practices as technologies, in their fundamental form (see Appendix 7 – Glossary of terms).

⁴ The term SMED used to describe set-up reductions was derived by Shingo (1986).

Whilst the technologies described above are certainly related to the processes and product, a more significant characteristic is that of the knowledge embodied in the heads of personnel. The knowledge of the way a firm's processes are utilised and products produced is held in the heads of the employees (Nonaka and Takeuchi, 1995). Recognising Kedia and Bhagat's (1988) typology that technological knowledge has elements embodied in process, product and person supports the argument that knowledge is embodied both physically and intangibly. Furthermore, Iansiti and Clark (1994) argue that knowledge and knowledge creating activities are the foundation of capability.

This knowledge-based outlook is a development of the resource-based and capabilities-based views of the firm, which have come to recognise knowledge as "the most critical resource and the determinant of a firm's capacity to confer sustainable competitive advantage" (Nonaka and Takeuchi, 1995).

3.4.1 Components of technology

Having considered the nature of the technology being investigated, it is appropriate to review the literature in order to establish what technology actually is.

In his definition of technology, Roberts (1977) emphasises the relevance of experience or acquired knowledge and points out that technical knowledge includes not only the engineering aspects of a production process (usually codified) but also the "know how". "Know how" is defined as the capacity to efficiently use technical knowledge, which in itself is further broken down into pure technical knowledge and skill born from participation (Roberts, 1977).

Similarly, Baranson (1969), in the context of technology transfer conceptualised industrial technology to include: “product design, production techniques and managerial systems to carry out production plans.” He goes on to explain that technological knowledge consists of not only engineering drawings, product and process specifications but also the ‘know how’ of high calibre engineering and technical personnel.

Hetzler (1969) defines technology in terms of three main factors: techniques, tools and machines. Whilst tools and machines are clearly physical objects, techniques are social prescriptions or procedures which bridge the gap between humans and the tools or machines.

Summarising the arguments of the authors above, technology has two major components (Figure 3-2):

- a) Physical objects.
- b) Knowledge or know how. This component can be further broken down into two further sub-components (Nonaka and Takiuchi, 1995).
 - (i) Codified knowledge
 - (ii) Tacit knowledge.

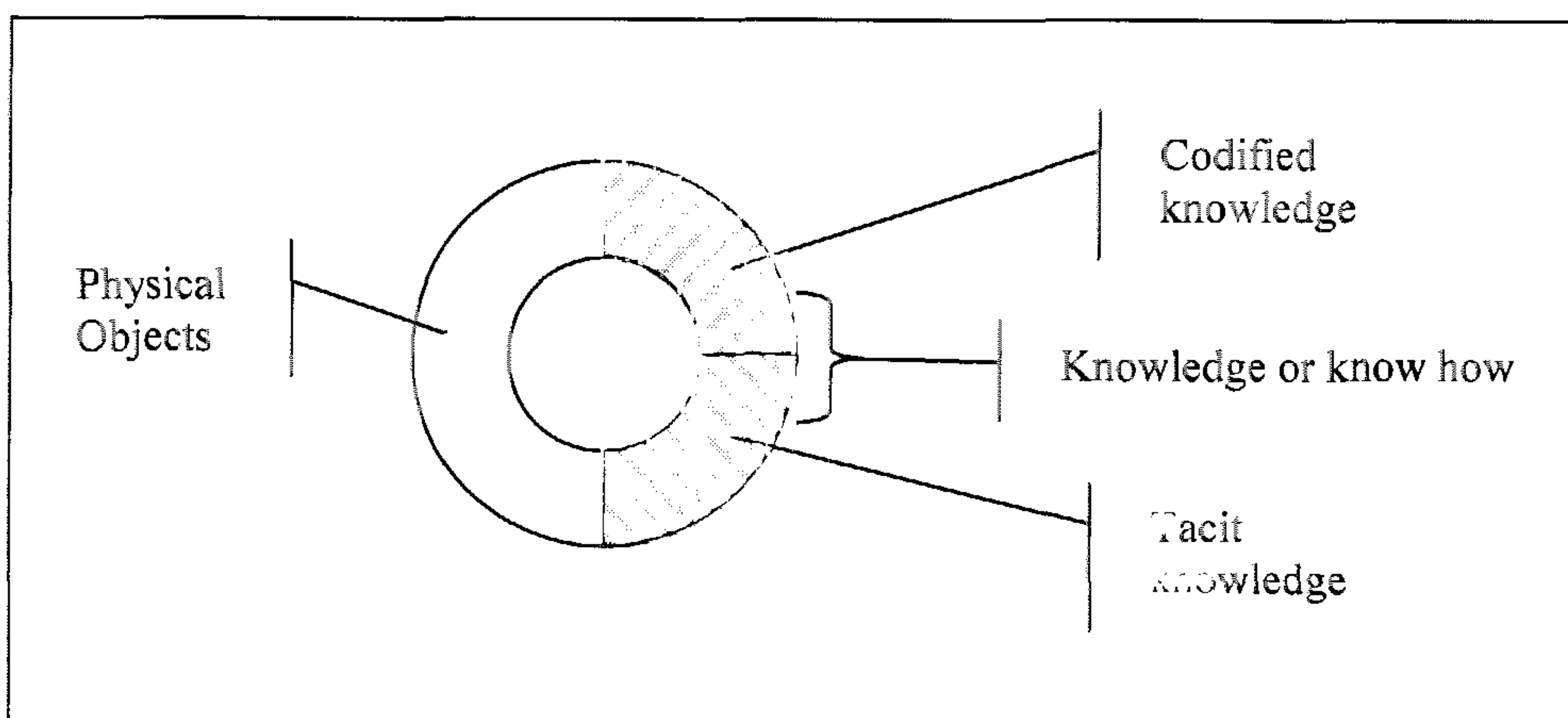


Figure 3-2 Graphical representation of technology

Following the specified boundaries of the technology considered it is appropriate to look at the elements of the technology to be transferred.

3.5 Knowledge

In literature describing technology transfer, authors often refers to technology as 'knowledge' (Dahlman and Westphal, 1981; Ounjian and Carne, 1987) and suggest that the transfer of technology is consequently an issue of transferring knowledge (Emmanuel, 1982). Furthermore, knowledge transfer is seen as a process in which an organisation re-creates a complex, causally ambiguous set of routines in new settings and keeps it functioning (Szulanski, 2000).

In his discussion of adaptive processes, March (1991) distinguishes between exploitative and exploratory learning. Simplifying somewhat, exploitative learning pursues efficiency gains, manifesting itself in enterprise behaviour primarily through a concern with things such as cost and prices. It tends to take the object of its learning for granted and aims to acquire a complete and detailed knowledge of it as an object facility. One example of deliberate exploitation at work is provided by the experience curve in which product-related learning, whether secured through repetition or scales effects, is pressed into the service of driving down cost (Henderson, 1979).

Exploratory learning, by contrast, generates new options - Japanese car manufacturers in the 1980s were securing competitive advantage for their cars by taking items that had previously been considered as extra accessories in the western car models and including them as standard features. In so doing, they challenged the tacitly entrenched ideas of the western automobile manufacturers (Womack, Jones and Roos, 1990).

It is therefore appropriate at this point to analyse technological knowledge to obtain a better understanding of precisely what is being transferred. The approach taken below is to consider the role of knowledge within the firm and then the measurement, and types of knowledge.

3.5.1 Knowledge in individuals and the organisation

Whilst there are many supporters of organisational learning (Senge, 1990; Argyris, 1992; Hedberg, 1981; Kim, 1993; Nonaka, 1991; 1994; Spender, 1989), others such as Cross (1996b), Cusumano and Elenkov (1994) and Cross and Baird (2000) view the firm as the co-ordination and integration of individual's knowledge. In view of the fact that technology transfer is heavily dependent on individuals, particularly the transferor, the recipients and those responsible for the implementation (Nonaka and Takiuchi, 1995). The individual as the knowledge holder/owner is key to understanding the process and difficulties of the transfer of knowledge, it is therefore more appropriate to consider the individual case rather than the organisational case.

Prahalad and Hamel, (1990) propose that the core competencies based on mental models and individual know-how and know-why is inimitable by competitors. However, as Teece et al. (1997) point out, it is also difficult to transfer not only within the firm but also to a partner.

3.5.2 Stages of knowledge

Jaikumar and Bohn (1986) and Bohn (1994) have developed a typology of eight stages of technological knowledge, see Table 3-1. They suggest that, as a process matures and is better understood, the knowledge associated with the process move up through these

stages. Low stages of knowledge are tacit, whilst at the higher end of the scale they reach stages such as know-how and know-why - enabling codification of the variables which effect the process. Bohn (1994) categorically links lower stages of knowledge with difficulty of transfer.

Stage	Aware	Current	Typical form of knowledge
1	Complete ignorance		Nowhere
2	Awareness	Pure art	Tacit
3	Measure	Pretechnological	Written
4	Control of the mean	Scientific method feasible	Written and embodied in hardware
5	Process capability	Local recipe	Hardware and operating manual
6	Process characterisation	Tradeoffs to reduce costs	Empirical equations (numerical)
7	Know why	Science	Scientific formulas and algorithms
8	Complete knowledge	Nirvana	

Table 3-1 Stages of Technological Knowledge - Bohn (1994)

Jaikumar and Bohn (1986) suggest that different parts of a process can contain different stages of knowledge at the same time and although a high level of knowledge may be desirable about a process, some variables having low levels of knowledge often exist, even in mature processes. This recognition is similar to that of Courtial and Sigogneau (1995), who refer to Maïsseu’s (1995) technology network model, stating that the same or similar technology may be strategic at different times whether from an academic, industrial or commercial point of view.

In contrast to tacit knowledge, codified knowledge is easier to manage. This is due to it’s ability to be recorded and explained (Nonaka and Takeuci, 1995), which clearly makes transferring technology more difficult. The following section seeks to analyse the two.

3.5.3 Tacit and codified knowledge

In order to understand the complexities of knowledge within the context of technology transfer, it is appropriate at this point to discuss the components of tacit and explicit (or codified) knowledge.

When discussing tacit/codified knowledge, authors often refer to the original work of the late Hungarian philosopher Michael Polanyi (Nonaka and Takeuchi, 1995; Teece, 1981b; Berman and Wallender, 1976). In their attempt to explain tacit knowledge, Nonaka and Takeuchi (1995) use Polanyi's (1958) often used quote:

“we can know more than we can tell”.

This quotation gives an excellent insight not only into what is meant by the term tacit knowledge, but also into the difficulties associated with the transfer of knowledge.

The idea that tacit knowing involves knowledge that is unarticulated, uncoded or unformalised is now often reported (Nonaka, 1991; Garud and Nayyar, 1994; Hu, 1995; Gupta and Govindarajan, 2000). Due to the emphasis that many researchers put on tacit knowledge in the context of technology transfer, consideration is now given to the wealth of literature to gain a better understanding of what tacit knowledge actually is.

Grant (1996b) proposed that “most of the knowledge relevant to production is tacit”. Conversely however, Howells (1996) notes that “it is likely that those areas of knowledge that are *truly tacit* in nature will be seen to be smaller than actually thought. More elements of tacit knowledge may in reality be, if not fully liable to codification, at least capable of being incorporated in an organisational routine”.

Clearly, there are different opinions relating to tacit and codified knowledge which in turn will have ramifications in the process of technology transfer. These will be highlighted in the following literature review.

3.5.3.1 Investigation of tacit knowledge

Even though codification through motion study can record some of the muscular acts that contribute to a skill, they are inevitably incomplete (Nonaka and Takeuchi, 1995). This follows the principle that a skill cannot be acquired merely by learning to perform its fragments. The knack of co-ordinating them effectively must be discovered (Polanyi, 1962). Nelson and Winter (1982) refer to this aspect as ‘programmable’ and they illustrate it with an example of a learned work programme whereby a typist can type common words without thought but is likely to slow down to type words which are unusual with strange spellings. Nonaka and Takeuchi (1995) present an excellent example of the tacit knowledge learning at Nissan during the first three years of the ‘Primera’ project. In particular, Nissan sent almost 1500 people from their design, testing, production, and marketing departments to acquire tacit knowledge about the European automobile market, motoring culture and road conditions, realising the big difference between being told about something and experiencing with their own bodies.

Pavitt (1988) states that technological knowledge is tacit and cumulative, and like competence at sport, it can only be learned over time (Rosenberg and Frischtak, 1985). Acceptance of the time-dependence of these activities suggest that experience is the source of learning and development, coming from personal assimilation of tacit knowledge (Hendry, 1995).

As a manufacturing process matures, some know-how and know-why become codified in rules of thumb, (also called heuristic knowledge) manifested in behaviours and captured in working routines and tacit actions (Repenisch and Ferretti, 1995; Teece et al., 1997), and to some extent becomes subconscious. Consequently, problem solving and fault-finding skills improve over time as they are based on the application of accumulated experiential knowledge (Dahlman and Westphal, 1981). This ultimately results in activities such as process tweaking and optimisation, start-up sequences and tricks kept in mind being tacitly embodied in a few heads (Behrman and Wallender, 1976).

As a process evolves and procedures are optimised, documentation is less able to accurately represent the actual operating practice (Behrman and Wallender, 1976; Myers and David, 1992). Detailed instruction and procedures such as work instructions typically consists of a list of activities to be carried out in a sequence. The instructions neither communicate the ability to perform the sub-skills with the requisite ability, nor assure the smooth integration of them into the main skill (Nelson and Winter, 1982), confirming that there is a gap between documentation and operational reality that is linked with tacit knowledge.

Summarising the above, tacit knowledge is a function of: (i) Learning by doing over time – developed from repetitive tasks and rooted in personal experience, and (ii) It cannot be recorded – tacit knowledge bridges the gap between documentation and actual operational reality.

3.5.3.2 Invention of codified knowledge

The converse of tacit knowledge is codified knowledge which can be articulated, recorded and easily passed on or transferred in the form of written instructions, engineering drawings, specifications, etc.

Due to the difficulties in communicating tacit knowledge, there is a growing call for increased methods of codification. Hansen et al (1999) propose that firms should develop their knowledge management strategy to match their competitive strategy. They report the case study of the firm Ernst and Young executives who employ some 250 people at their centre for business knowledge where teams of specialists write reports and analyses for access by other members of staff. This person-to-document codification is reputed to have saved many thousands of dollars in search time. Similarly, Davenport et al (1998) report the case study at Hewlett Packard's corporate education division where a knowledge project was used to capture tips, tricks, insights and experiences into a Lotus Notes database and making them available to over 2000 staff. An excellent example of firms using computer technology to share hard earned knowledge, a concept which Cross and Baird (2000) suggest is a growing trend.

3.5.3.3 Distinctions between tacit and codified knowledge

The previous 2 sections have analysed and explained the content of both tacit and codified knowledge. However, in order to summarise the distinctions between the 2 types, Nonaka and Takeuchi (1995) present an excellent comparison to help clarify understanding, see Table 3-2.

Tacit knowledge (Subjective)	Codified knowledge (Objective)
Knowledge of experience (body)	Knowledge of rationality (mind)
Simultaneous knowledge (here and now)	Sequential knowledge (there and then)
Analogue knowledge (practice)	Digital knowledge (theory)

Table 3-2 Two types of knowledge - Nonaka and Takeuchi (1995)

Knowledge is clearly recognised as being a difficult and complex subject to master. To manage the transfer process of knowledge across international borders requires not only an understanding of the distinctions between the tacit and codified elements but other dimensions as well.

3.5.4 Maturity

Using Teece's (1981a) codification, Contractor (1991) states that the ability to transfer a technology increases with its maturity and that the host can 'unbundle' the technology as it progresses along the life cycle. Supporting the theory that it is easier to transfer technology that has matured and is better understood, Bohn (1994) reports that the level of knowledge is related to the transferor's experience of using the technology and experimenting with it.

It is not difficult to recognise from the above that the effectiveness of manufacturing best practice technologies will improve as the tacit knowledge embedded in the organisation increases with use. The positive side of this phenomenon is that the practice is better understood and the users become *experts* in its application. The negative side is that as the tacit element increases codification is more difficult and the transfer process is limited to largely on-the-job training.

3.5.5 Stickiness

A recent concept introduced into the world of technology transfer is that of ‘stickiness’, a term introduced by Von Hippel (1994). Stickiness is used to describe the difficulty of knowledge flow within companies, whereby due to the tacit elements, an amount of knowledge remains (or sticks) with the home site (Iansiti, 1998; Szulanski, 1996). Both Iansiti and Szulanski stress that the inability of an organisation to clearly transfer knowledge internally increases difficulty and costs significantly during the copying of best practices. However, whilst there is clear recognition of the fact that tacit knowledge ‘sticks’ and is costly to transfer, there is no real appreciation of the relationship between the degree of ‘stickiness’ and the difficulty/costs.

3.6 Technology transfer

Technology transfer has attracted an enormous amount of research activity over the past 30 years with many authors representing their technology transfer processes using models. To enable a pre-assessment of technology transfer to be made, it is necessary to first understand the process and what is involved. This section will initially look at the generic structural model and then consider other contributions

3.6.1 Structural models

Figure 3-3 demonstrates a generic model which is similar to the models developed by Reddy and Zhao (1990), Keller and Chinta (1990), Tsang (1994), Mansfield (1974), Ounjian and Carne (1987) and Teece (1981a). The generic model represents a holistic view of the entire process and consists of four major elements:

1. The characteristics of the home site.
2. The characteristics of the host site.
3. The properties of the transfer process
4. The nature of the technology content.

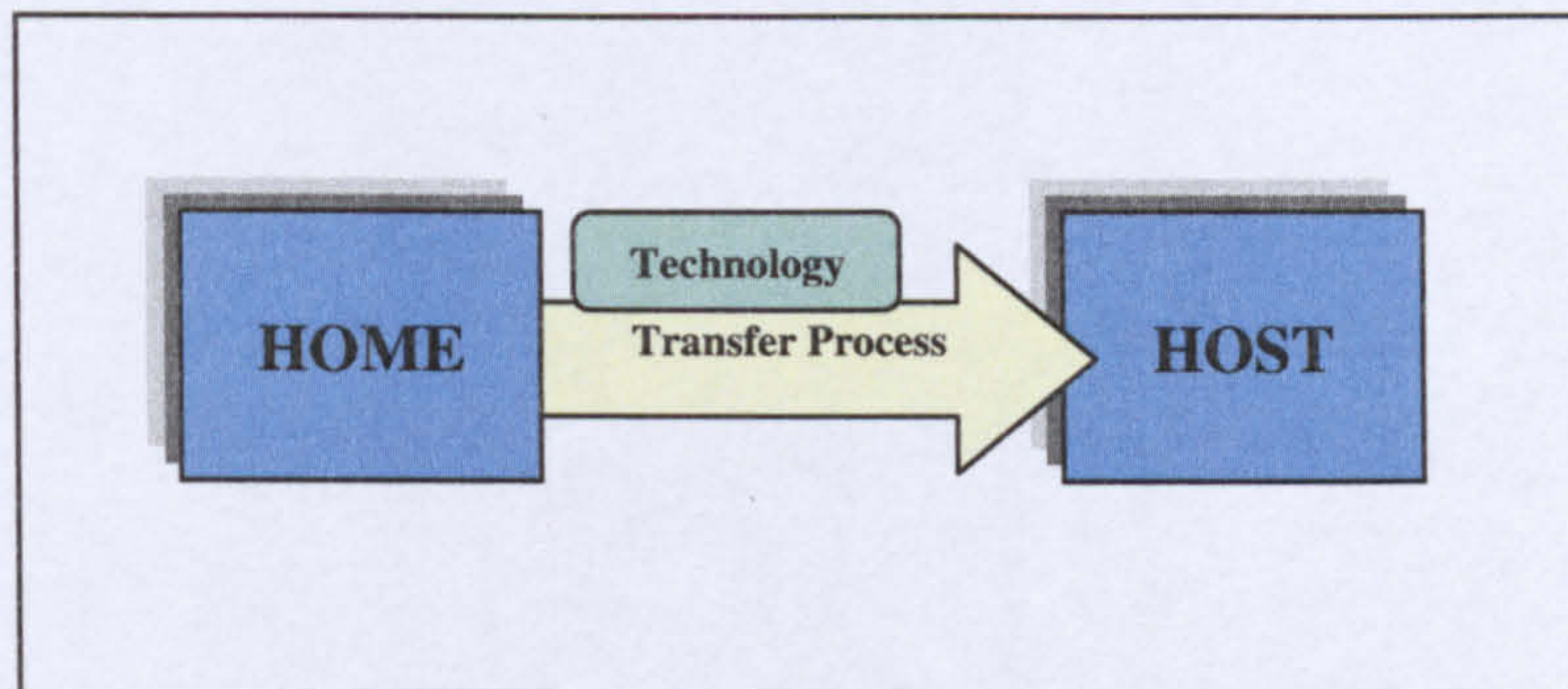


Figure 3-3 Generic Model

The generic model lays a foundation to describe the entire process and transfer environment suggested by Aharoni (1991), and proposes interrelationships between the nature of the technology, the choice of transfer channel, and the characteristics and capabilities of the home and host (Behrman and Wallender, 1976).

Studies into international technology transfer have investigated individual aspects of the model in an attempt to explain the process. Major contributors include:

Samli

Samli (1985) who has developed what he calls a 'general model' of technology transfer shown in Figure 3-4. This includes six dimensions of technology: geography, culture, economy, people, business and government.

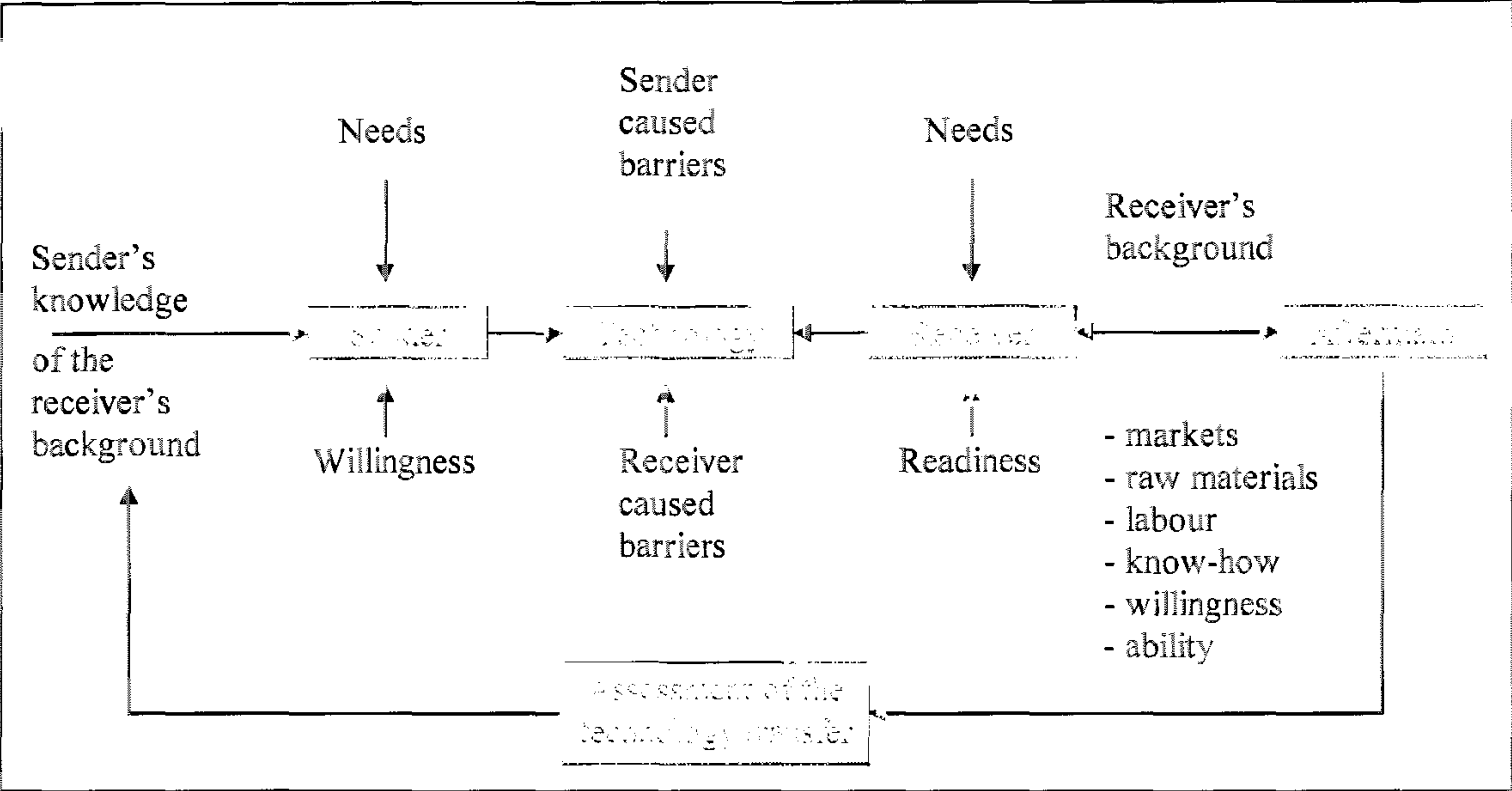


Figure 3-4 General Model of Technology Transfer - Samli (1985)

Samli’s general model provides an insight into the key components of technology transfer, namely the sender, the technology, the receiver, the aftermath and the assessment. However, one important element missing from the model is the transfer process, which is the mechanism by which knowledge is passed from the sender to the receiver.

Collett

Looking more towards the home and host effects (direct effects) and content effects (process-mediated effects), Collet (1994) provides an important platform to bring together these effects.

Direct Effects	Process-Mediated Effects
<ul style="list-style-type: none">• Country of origin• Economic, political, social situation• Site attractiveness• Exchange rates and duties• Supplier situation	<ul style="list-style-type: none">• Human resources and cost• Physical resources and cost• Technological infrastructure• Transport, information and service infrastructure

Figure 3-5 - Structural Factors which Influence Node Strategy - Collet (1994)

Behrman and Wallender

Behrman and Wallender (1976) present a ‘Technology Transfer Matrix’ focusing on three phases prior to transfer to transfer and four subsequent. The relationship between the types (or phases), of technology and the mechanisms to transfer them is conceptualised in a matrix, Figure 3-6.

Technology Phases	Documentation		Instruction		Conferences and Seminars	Visits and exchanges	Apprenticeship	Other selection of Personnel
	Manuals, Recipes, Diagrams	Reg. or Reports	Formal	On-the-job training				
Conceptualisation								
Product Design								
Plant design and Construction								
Start-up								
Plant Engineering and Controls								
Process Development								
External Support								

Figure 3-6 Technology transfer matrix - Behrman and Wallender (1976)

The proposed matrix encompasses the communication and information aspects of the process mapping them against the phases of introduction of a technology, aiding the transferor to evaluate mechanisms. However, there are a number of assumptions particularly relating to resources and co-operation at (and between) both the home and host sites.

Researchers within the Centre for Technology Management (CTM) at Cambridge University have developed a framework for manufacturing transfer which is reported by Steele et al (1997) and Grant et al (1997), and is shown in Figure 3-7.

Issues	Strategic Planning	Reporting	Planning	Managing and Controlling	Transferring	Assessing	Reviewing
Activities							
Capabilities							
Resources							
People							
Integration & Interface							
Staff							
Human Resources & Development							
Skills							
Knowledge							
Organisation							
Structure & Relationships							
Quality							
Financial Performance							

Figure 3-7 Framework for Manufacturing Transfer - Steele et al (1997) and Grant et al (1997)

Steele et al (1997) map their observations of four longitudinal case studies to the framework suggesting it to be a “useful and comprehensive structure”, supporting Meredith et al’s call for a “useable solution” (1989). Steele et al (1997) group Simon (1991) and Ramanathan’s (1994) considerations of tacit knowledge, suitability of working practices, host infrastructure and organisational structure and other non-technical aspects into:

- Fitness of the home firm to transmit. (How willing to adapt? How experienced with transfers?)
- Fitness of the host to receive. (How able to learn?)

Minshall

Minshall, one of the researchers within the CTM at Cambridge University has used the framework shown in Figure 3-7 as the foundation of a workbook to guide manufacturing companies with the transfer of production technology across geographical boundaries, Minshall (1999).

Szulanski and Winter

Szulanski and Winter (2002) propose guidelines for replicating best practices which are largely based on the Intel ‘copy exact’ methodology (McDonald, 1998). The prime drivers being: copy something that’s worth copying, work from a single active template, copy as close as possible, adapt only after acceptable results have been achieved. The strong argument of not changing anything until its established does not fully recognise that some technologies *must* be modified to suit different cultures, markets and management styles.

Kedia and Bhagat

Kedia and Bhagat (1988) construct a model around the cultural characteristics of the home and host, and the type of technology involved to hypothesise the success of the transfer. The subject of cultural differences will be investigated in detail and critiqued later in section 5.4.1.

Lall

Lall (1980) uses the nature of participation, the complexity of the technology and the relative capabilities of the two parties to predict the type of transfer channel chosen.

Hemais

Hemais (1995) proposes a model of technology transfer flow which includes: home market, characteristics of the technology, barriers created by foreign governments, the firms attributes and characteristics of foreign market. Predominantly recognising barriers in the channel created by foreign governments and characteristics of the foreign market.

Woodward and Miles

Woodward and Miles (2000) present a technology transfer maturity grid based on Crosby's (1979) 5 stages of understanding. However, whilst the grid takes into account the sender, recipient and transfer method it does not recognise the issues present during international technology transfer.

Grant and Gregory

Grant and Gregory (1997) review other dimensions of technology transfer that affect the ability to transfer:

- Appropriateness - A process that can be transferred unadapted to fit given host conditions.
- Robustness - A process that can be transferred unadapted to fit any given host conditions.
- Transferability - A process's innate, host independent ability to be adapted (where necessary) within reasonable time and resource constraints.

The characteristics of the models described above cluster and map very well onto the generic model of technology transfer (Figure 3-3). They recognise important attributes that should be included when considering the function of the home, host, technology and

transfer process. These contributions must be taken into account within the assessment phase of the overall pre-transfer assessment framework (Chapter 5).

3.6.2 Discussion of the models

Samli's model includes most elements that would need to be considered when transferring practices but it neglects to include the transfer process itself. In contrast, the Cambridge model includes the transfer process in detail. Although this model deals more with the transfer of manufacturing as a whole package, there are important aspects which contribute towards the international transfer of technologies described in section 3.4. Particular reference is drawn to the 'Packaging and Adapting' phase of the Cambridge model where changes are recognised as being necessary before the transfer phase can reach its full potential.

The models above emphasise the importance and difficulties of transferring information embodied in people. Viewed in isolation, each model only explains a subset of the technology transfer decisions. None of them explain the complete picture. As Afriyie (1988) notes: "despite the rich collection of studies on technology transfer, key issues ... remain unresolved regarding the nature of the technology itself, on the one hand, and the transfer process, on the other".

There is certainly a need to develop a model that will improve the understanding of the transfer process with helpful explanatory capabilities.

3.6.3 Fitness for transfer (Workbook)

In parallel to this research, Grant of the manufacturing group at Cambridge University has extended his PhD research and developed a workbook to aid project managers in assessing the ‘fitness for transfer’ prior to the ‘packaging and adapting’ phase of the transfer process outlined by Steele et al (1997), see Figure 3-7, Grant (1999).

The fundamental difference between Grant’s work (1999) and this research lies in the fact that his workbook has been designed around manufacturing transfer – the transfer of manufacturing processes to produce a product rather than the generic and firm specific technologies to improve competitive capabilities – what Smart (1996) describes as ‘best practices’.

3.7 Gap in current knowledge

The literature reported above has outlined various forms of technology transfer models, and numerous characteristics of the components: home, host, transfer process and technology content to explain the process of technology transfer. Within the literature, the activity of pre-transfer assessment is reported as being important but no useful framework to guide an assessor as to where the difficulties will lie has been identified.

The research investigation conducted by the author has focussed on the development of a framework that an assessor can use to help a firm transfer the technological knowledge embodied in people from one site of an MNE to another.

3.8 Summary

This Chapter has described the current situation in global manufacturing and highlighted the importance of the multinational enterprise as the main agent for firms to operate

globally. The competitive capabilities MNEs must develop has also been recognised along with the prime method firms use to maximise their manufacturing competitive advantages – technology transfer. However, whilst much research has addressed the issues relating to the transfer of technology, the literature survey has identified a gap in the current knowledge – the pre-transfer assessment phase. Many authors refer to it but there are no models, guidelines or structures proposed. This shortfall has formed the basis for this research.

The following Chapter will report the observations made during the case studies in Rittal, ALSTOM Power and Nissan Motors UK.

CHAPTER FOUR CASE STUDIES

4.1 Introduction

The previous Chapter has identified the gap in current knowledge relating to international technology transfer – that is, a pre-transfer assessment framework whereby transferors can predict the problem areas ahead of them. Specifically, the technology identified as being that which is to be transferred are the practices used by a firm to obtain competitive advantage through using their machinery and equipment on their own products. Typically, the technologies have a high tacit knowledge content.

This Chapter will describe the results of detailed case studies undertaken by the author in the Rittal organisation, ALSTOM Power and Nissan Motors UK. The salient findings will be grouped and analysed for inclusion into a new approach to pre-transfer assessment of technology transfer.

4.2 Case studies within the Rittal organisation

Table 4-1 and Table 4-2 provide details of specific instances of technology transfers between Rittal sites. Table 4-1 reports the observed case studies of which the technology being transferred is of a generic form. That is, technologies which can be found in many companies but are tailored in their application for best use within the company. Table 4-2 reports the observations made during the same case study site but the technology can be

described as being directed at the way the product is made. Focusing on making the product and process difficult to imitate.

Data was collected during various factory visits between January 1996 and April 2000. As described in Chapter 2.6, part of the author's job is to help develop the factories in India and USA. These activities have produced important contributions within the action research where case studies of technology transfers were investigated at both sites. During the research period, the author's duties have resulted in 12 visits to the Indian plant and 7 to the USA plants (see Appendix 6 for details). Additionally, there were some 15 visits to the factories in Germany. During all visits, the author was hosted by the senior management of the factories and discussions were open and detailed. In each case study reported, the author carried out semi-structured interviews with operators, supervision and managers covering the issues of implementation and usefulness of the technology. Additionally, the author has physically witnessed the technologies in live use to gain an understanding of the real working of the technology and level of success of the transfer.

4.2.1 Generic Technologies

Table 4-1 below presents the transfer details of generic technologies used within different sites of the Rittal group. For the purpose of this work, the author is not interested in the technology per se. Rather he is concerned with aspects surrounding the way it was transferred.

It should be noted that Table 4-1 reports the technology introduction at the highest level. For example, where the principle of controlling the supply of flat parts is described only once for a particular site, in reality, the application was to more than 100 parts. Similarly,

the application of ‘Single minute exchange of dies’ (SMED⁵) described below suggests that it was only introduced onto large power presses. Again in reality, it was applied to many machines including power presses, brake presses, turret punches and some assembly areas.

Technology	Transfer details		Transfer issues	Observations
	Transfer origin	Technology application		
<u>Kanban</u> Utilised in the UK factory for small part manufactured in house along with fabricated parts and fasteners from suppliers and sub-contractors.	Germany	Large flat parts	Parts were painted ready for short delivery time of configured standard enclosures.	Observed by the group technical director whose encouragement helped the smooth introduction.
	USA	Large flat parts	Parts were required to be held pre-paint so that they could be painted in different colours and be used for special orders.	Humidity in the summer months results in components rusting if not painted within 24 hours.
	India	Small components	Regularly used components. Increases availability in assembly and increases flexibility in sheet metal.	Observed by the production manager of the Indian plant who also became the transferor.
<u>VISUAL FACTORY</u> Techniques used in the UK factory include the display of: <ul style="list-style-type: none"> • Training matrices • Quality performances • Activity sheets • Delivery performances • Departmental performances • Work-to-matrices • Planned maintenance schedules • Care points 	Germany	Activity sheets Quality performances	System to record the problems and shortages (output targets, quality problems, internal supplier problems, external supplier problems, labour shortages, etc) every hour in increments of 10 minutes. Displaying internal reject performance and customer complaint analysis.	Very difficult to sustain, not all parties within the host site believed the systems were necessary.

Table 4-1 Generic technologies (Continued below)

⁵ See Shingo (1986).

Technology	Transfer process		Transfer issues	
	Transfered to	Technology application		Comments
	USA	Activity sheets	Introduced to the production manager and left for introduction. Better outlined procedure would have given a better result.	The sheets were filled in but were not on display for everyone to see. This was a fundamental failing in the system as it became a reporting tool rather than a live decision prompting tool.
		Delivery performances Care points	Adopted as seen in the UK factory by the QA Manager from the Springfield site.	
	India	Training matrices	Adopted by the factory with enthusiasm and used within the sales and marketing department as well.	The hosts saw an immediate benefit and were self motivated to introduce the system.
		Activity sheets	Used in the manner it was intended but there is doubt as to whether the data is correct – too perfect.	
		Departmental performances		
		Work-to-matrices	This technology works well but took a total of 4 visits to embed the usefulness. Factory management believed that they could control the reasoning of 'sets' in their heads. The visual system enables everyone in the department to see the status of every ones targets.	Embedding took far longer than originally anticipated.
		Planned maintenance schedules	Adopted very quickly with enthusiasm.	One engineer stayed at the site for 4 weeks to help embed the systems.

Table 4-1 Generic technologies (Continued below)

Technology	Transfer details		Transfer issues	Comments
	Transfer from	Technology adopted in		
		Core Points	Introduced by the UK technical director.	Although the technology was accepted well. There has been no proactive drive to expand the technology into other areas nor to expand it in the areas where it already works.
<u>Just-in-Time delivery from suppliers.</u> Delivery of small parts from suppliers and sub-contractors	India	Delivery of small fabricated parts.	Infrastructure of roads, etc.	Sub-contractors are sited within 100km of the factory but delivery is very unreliable.
	USA	Supply of components.	Distances between large cities.	Due to the distance between suppliers it is very difficult to achieve daily deliveries. Note: Fasteners on Rittal products are metric but the common system in USA is imperial.
<u>Single Minute Exchange of Dies (SMED).</u> SMED techniques used in UK factory: <ul style="list-style-type: none"> One for one, tool changeover system Standardised tool clamp studding SMED techniques used in the German factories: <ul style="list-style-type: none"> Hydraulic tool clamping Automatic material removal SMED techniques used in USA: <ul style="list-style-type: none"> Material feeder system 	India	One for one, tool changeover system	Technique modified to suit different type of machine	
		Standardised tool clamp studding	Management saw the benefit immediately and embraced the technology.	
	UK	Hydraulic tool clamping	Adopted without modification	
		Automatic material removal onto next work station.	Being considered at time of writing.	
	UK	Material feeder system	The system was used to reduce waiting for forklift trucks.	Adopted as seen by the UK Technical Director

Table 4-1 Generic technologies

4.2.2 Firm specific technologies

Table 4-2 below considers ‘firm specific technologies’ which are used within the Rittal organisation where the technology is apparently available off the shelf but the application of the technology is that which provides a competitive advantage.

Technology	Transfer details		Transfer notes	Comments
	Transferred to:	Technology applied to:		
TIG welding with very high current and travel speed applied to external fillet welds so that the joint requires almost no post operation grinding. Developed in Germany	UK	Similar parts in shape and size.	Technology identified by the transferor on a site visit.	Parts were slightly modified to achieve the fit-up accuracy similar to that used in the home site. The technology was applied to 3 machines including one robot.
Large power presses used to blank and form components at high speed. Approach developed in Germany	UK	Smaller parts	Technology introduced by senior group management.	Large specialised machinery, making production difficult to imitate. The principle being that competition will have to make significant investment to enable the components to be produced.
Powder painting of product. This system is used to paint product in Germany, UK and USA.	India	Automated process applied to manufactured parts.	Acidity of water. Oil seeping out of ‘Dutch folded’ components shipped from Germany	Acidity of water in the pre-treatment affects the adhesion of the electrocoat paint. Changes are not quick but vary a lot. Viscosity of oil increases due to period in transit to India. Degreasing operation becomes far more difficult necessitating increased temperature and cost.

Table 4-2 Firm specific technologies (Continued below)

Technology	Transfer details		Transfer issues	Comments
	Transferred to:	Technology Applied to:		
Plasma welding applied to welding enclosure frames. Technology was new into industry and application into high volume production environment was developed between supplier and German factory.	UK and USA	Same product introduced in UK and USA	The technological demand on support staff was very high. The filler material was changed from powder to wire, enabling the technology to become more robust.	Technology modified to improve the effectiveness.
Roll-form process used to produce complex frame profiles.	USA	Same product introduced in USA	No other way of producing components which were designed against imitation.	Transfer process needed experienced staff to be transferred to USA for extended periods in addition to the installation team from the machinery manufacturers.

Table 4-2 Firm specific technologies

It should be recognised that in the plasma welding and roll-forming case studies, the manufacture of other components such as doors, side panels, etc. were not included because the technology used to produce these components are general and not 'firm specific'.

4.2.3 Codification

The technologies investigated have a high tacit knowledge content and make codification difficult. In almost every case described above there was only limited documentation accompanying the technology. Only in a few cases were component and assembly drawings of the machinery made available. The transfer process normally involved a combination of the following:

- Photographs and videos of the process.
- Extended periods spent watching the process.
- Explanation/discussions with operators and/or development engineers.

Whilst relatively unstructured, a surprisingly high level of ‘know why’ was gained in all cases. This is confirmed by the ability of the transferor to apply the knowledge gained into the host site. One interesting aspect of the studies is that, whilst traditionally the knowledge gained during the observation/discussion phase would normally be classified as tacit, only minimal on-the-job training was required. This suggests that a significant amount of the knowledge collected was ‘specifiably tacit’ (see Polanyi (1966); Grant (1997)). The above observations suggest to the author that, where the codified knowledge is understood, the tacit element (specifiable or not) in these circumstances is more to do with recognition of the application of the codified knowledge. One point worth highlighting is that many of the best practices described above were identified for transfer *by chance*. This appears to be a common occurrence and should be considered within the pre-transfer framework.

4.2.4 Communication links

During the action research in India and USA, it became evident that communication links back to UK or Germany were extremely difficult. This was due to two major aspects:

1. Time differences varied from 5½ hours ahead of ‘British Summer Time’ in India, to 5 hours behind in ‘east coast time’ (USA). This resulted in a very limited period when telephoning could take place.
2. Telephone links (land lines) within some parts of India can be very unreliable, sometimes becoming inoperable for several days – particularly during the monsoon season. This made communication with Europe difficult through telephone, facsimile, e-mail, etc. However, it is interesting to note that it has recently become possible to use mobile phones in these unreliable areas, although this is neither easy nor cheap.

4.2.5 Summary of salient observations at Rittal

By looking at the content of each case study, reported in Table 4-1, Table 4-2, section 4.2.3 and section 4.2.4, the emerging prominent issues can be clustered. A summary of the issues are listed below:

- **Observed by initiator.** Where the technology has been observed in operation by the person suggesting the transfer.
- **Initiator becomes transferor.** Where the person who suggested the transfer of the technology becomes the one who will carry out the transfer.
- **Belief of technology usefulness.** The buy-in of those involved at the host site that the technology will work in their environment.
- **Time needed for embedding.** Recognition of the time necessary for the new technology to be established.
- **Availability of some resources needed for embedding.** Personnel and resources necessary to implement and nurture the new technology.
- **Supplier infrastructure.** The capability of suppliers to support the new technology within the company.
- **Modification of technology.** The flexibility of the technology to operate in different applications.
- **Strategic directional trend. Influence from HQ.** The necessity for the technology to adapt to changing trends directed from the market for instance.
- **Natural environment.** The influence on the technology from the local environment, such as: temperature, humidity, acidity of water, etc.
- **Documentation.** The availability and suitability of drawings, specifications, planning sheets, etc.

- **Communication links.** The influences of time differences, language, robustness of telephone links, etc.

The next section of this Chapter will examine case study observations made at ALSTOM Power.

4.3 Case study within ALSTOM Power.

ALSTOM Power manufactures large steam turbine generators, predominantly for power stations. It was chosen as a case study site due to the author's working knowledge of the company and his relationship with its senior management. The author had worked for the company in the position of Production Co-ordination Manager for more than 2 years and has a good knowledge and understanding of the changes and developments carried out over the past 10 years. The author has carried out in-depth, semi-structured interviews with 2 senior managers within ALSTOM Power (see details given in Appendix 4) and, through his experience and knowledge of the company's operations, he has the ability to interpret information and data gathered. ALSTOM Power have manufacturing sites in UK, France, Germany and Mexico.

The case study investigation at ALSTOM Power has examined two aspects of high content technology transfer. The first aspect to be considered is the context for sharing technological advantages within the manufacturing sites and secondly, a specific case study is examined regarding the transfer of a large amount of their technological know-how to a customer in China.

4.3.1 Working parties

The company-wide transfer of technology is strongly supported by the Senior Management of ALSTOM Power. 'Working Parties' are organised between manufacturing managers of each site during which the means of achieving benefits and enhancements are freely shared. Areas covered include methods for reducing costs or lead times and for improving quality.

Working parties of business unit managers are formed to transfer the best of the best practices from one site to another. The business unit managers are encouraged to travel to and from sister sites on a monthly basis. This means that the manufacturing manager of say the Diaphragm Workshop in Rugby is encouraged to travel to St Florent in France on a Friday, spend the weekend with the French manufacturing manager and carry out the formal business on the Monday. This practice not only facilitates the transfer of best of the best practices but also helps to form good working relationships between managers of different sites. On a three to six month basis, the results and progress of the working parties are reviewed by the French and British Production Directors and Works Managers. Each working party reports the results of previously completed transfer projects and progress of current transfer projects.

It should be noted that, following the merger of the British and French elements of ALSTOM Power in 1989, the attitude on both sites was one of mutual distrust. Practices were protected and co-operation between sites was poor. Following some eleven years of working together with encouragement from very senior management, the culture has changed to one where both French and British can see that sharing best practices is a sensible way to go forward. The company encourages its management to meet and socialise together so that they co-operate with each other and eliminate distrust. Such co-

operation has led to dramatic reductions in lead-times (in some cases such as the manufacture of high pressure rotor blades, from 12 weeks to 10 days) and large cost reduction programs in areas which are recognised to be very difficult within a high technological involvement.

4.3.2 Technology transfer from UK to China – Ling Ao Power Station

As part of a major contract to supply turbine generators to China, ALSTOM Power agreed to 15% of the project to be manufactured locally - in China - with the target to enable full self-reliance. That is, full documentation and full 'know how', treating the host manufacturing site as a sub-contractor. To manage the transfer process a team of three engineers, including one manager, was set up.

Documentation included drawings, quality plans, work instructions and CNC programmes were provided. In addition to the codified knowledge, the methods and techniques were recorded on video and by digitised photographs - expressible tacit knowledge (Nisbet, 1969).

The management of the codified and expressible tacit knowledge was by using an 'Information Transfer Software'. This enabled the information to be retrieved through a logical hierarchy. The use of information technology was a great advancement over previous similar contracts where the management of the information was through a book.

To embed the truly tacit knowledge a three phase visit plan was agreed:

1. Home visit to Rugby by Chinese engineers for 160 man weeks.
2. Permanent expatriates to work at the host site, Ling Ao, problem solving.

3. On site experts to work for the duration of the manufacture.

This particular contract is seen as something of a case study for the company due to the high percentage of local build and vast amount of technology transfer.

This case study has particular relevance to the research in as much as ALSTOM Power are structuring technology so that it can be packaged and transferred, albeit with the traditional on-the-job training at both the home and host sites for the tacit knowledge. At the time of writing, the contract has not reached the stage where the knowledge will be unpacked and consequently the author is unable to assess the success of the system. However, it is encouraging that where large knowledge contents are involved it appears that efficient structuring and packaging may need to rely on software.

4.3.3 Documentation case study

During the manufacture of a large rotor shaft at one of the French production sites, it was recognised that a machine overload existed and the decision was taken to carry out the final machining operation at the German factory. The operation was to drill the flange which is used to bolt the next rotor to the one in question.

The French planning sheets and drawings were transferred along with the part-finished rotor to the German factory. However, although the format of the French planning sheet was similar to those used in the German factory, they were not identical. Each box on the planning sheet clearly described the contents but in French which the German machine operator could not read and believing the format of the planning sheets were identical drilled the rotor with the wrong number of holes at the wrong pitch circle diameter. The rotor shaft was scrapped at a cost far in excess of £100,000.

This case study reconfirms the need to standardise on documentation including the language when transferring between sites internationally.

4.3.4 Summary of salient observations at ALSTOM Power

A summary of the content of the transfer issues observed in the case studies at ALSTOM are listed below:

- **Initiator becomes transferor.** Where the person who suggested the transfer of the technology becomes the one who will carry out the transfer.
- **Influence from HQ – senior management.** Strong encouragement from the senior management at the headquarters for technologies to be shared.
- **Documentation: Drawings, specifications, etc.** The availability and suitability of drawings, specifications, planning sheets, etc.
- **Documentation: Standardised language and format.** The availability and suitability of drawings, specifications, planning sheets, etc. written in a language, and layout that the user can understand.
- **Time spent at home site by host transfer team.** Personnel and resources from the host site, necessary visit the home site to witness and learn the new technology.
- **Time spent at host site by home transfer team.** Personnel and resources from the home site, necessary to implement and nurture the new technology.

4.4 Case study within Nissan Motors UK

The case study material in this section was collected from the car manufacturing plant Nissan Motors United Kingdom (NMUK) in Sunderland. The author has chosen NMUK due to the high reputation (Nonaka and Takeuchi, 1995; Womack et al, 1990; Wickens, 1987) the plant has regarding their capability and use of modern manufacturing techniques

and practices. Additionally, the author has a working relationship with one of the senior managers and has the facility to contact him in an informal manner to clarify anomalies.

Data was collected from NMUK from between September 1998 and May 2000 during which the author made 3 site visits and conducted 3 semi-structured interviews (see Appendix 5 for details), these were conducted with two of the senior staff who are directly involved with technology transfer from Japan.

4.4.1 Directional trends

Within the global organisation of Nissan, each manufacturing site is expected to perform financially as a stand alone profit centre. This ethos creates a difficult situation for the head quarters in Japan to dictate which technologies each site shall use. The approach instead is to *propose* 'directional trends', such as the use of standard operations, supplier development teams, kaizen improvement activities, etc. Consequently, many of the generic technologies were introduced during the early stages of the plant start up.

4.4.2 Advisers

The plant at Sunderland has 35 Japanese advisers permanently on site each of whom have an expertise in a particular field. Part of their responsibility is to not only give advice on their own subject but also to help with the introduction of new technologies and collect new technologies developed at NMUK and transfer them to other plants within the group.

In the same way as the directional trends are proposed, the advisers suggest that a new technology may benefit the site. Due to the advisers experience and standing within the organisation, if a technology will not be adopted then the host team will need a very strong

argument for rejecting it. However, it is normal that someone from NMUK will travel to the site where the technology is working to witness the success. This process has a very high adoption rate and usually has the added benefit that the visiting engineer will see other useful technologies at the same time.

4.4.3 Intra-firm general competitiveness

The general trend of international competitive drivers has been changing over the past 10 years, (De Meyer 1997). Whereby quality and delivery were previously seen as being most important with cost (or price) being third, trends are now moving towards quality and delivery being expected and a strong focus on cost being the new top key driver. This shift has been experienced heavily by NMUK and the company are now refocusing their strategy of technology introduction.

This focus on cost is not only to remain competitive within the automobile market but also to achieve competitiveness against other manufacturing sites within the global Nissan organisation. Individual factories within the Nissan organisation will compete against each other for the approval to build new models such as the new Micra. In exactly the same way, Volkswagen's decision to manufacture the new Beetle in Puebla, Mexico, was the result of a lengthy review in which the Puebla site was compared with sites in Germany and Eastern Europe, (Lau and Ngo, 2001).

To this end, great care is placed on the comparative measurements which have now become an intra-firm technology in themselves. Similarly, all proposed technologies which could potentially yield cost savings are considered very carefully before being prioritised for implementation.

4.4.4 Firm specific technologies

Within this case study site, the use of generic technologies was designed to be used before the factory was built (Womack et al, 1990). Consequently, the vast majority of the research related to the firm specific technologies. Table 4-3 reports the detail.

Firm specific case / context	Transfer details	Issues
MOVING SHUTTLES FOR LOADING OF DASH-BOARD INTO CAR NMUK to Japan The problem was that assembly operators had to fit the dashboard into the car as it was moving along the main drive conveyor. This was a difficult task for the operator to carry out due to the fact that the dashboards are heavy and the ergonomics for the operator put strain on their backs and shoulders. The operation was costly and the work-station operators suffered from high sickness levels. The solution was a moving platform which travels at the same speed as the conveyor with a device for taking the weight of the pre-assembled dash-board. The technology was transferred into every Nissan plant world-wide.	The technology was identified by the advisors and transferred with minimum modification. That being to adapt to the type of vehicle being assembled.	Transferor being from head quarters and transferred the technology to the other host sites.
ASSEMBLY LINE FEEDING BY CAROUSEL NMUK to Japan A method of presenting stillages of parts to the assembly line operator was developed at the Sunderland plant. This enabled the fork-lift driver to change the kanban stillage without endangering the operator. The changeover operation is a 180° rotation, pneumatically activated.	Transferred as seen	The system has been adopted in most of the factories in Japan.
STANDARD OPERATIONS NMUK to Japan A method of presenting an agreed method of carrying out an operation. Standard operations have each individual movement of the operator recorded along with assessments of posture, tools, safety equipment, operation times etc. They are designed to eliminate any ambiguity between operators and supervision and also shift to shift. Nissan view the standard operations as the unequivocal way in which a job shall be done.	Some difficulties at first due to the Japanese reliance on the management of tacit knowledge. That is, not wanting to try to codify it.	Standard operations are now an accepted method of agreeing procedures throughout the Nissan organisation.
‘ILU’ SKILL MONITORING SYSTEM Japan to NMUK and then NMUK to Japan The ILU system of presenting skill levels of the operators in a work area is used to ensure there are sufficient operators available to ‘man up’ all jobs at all times. This is one of the foundation systems within the ‘Nissan Production System’. The ILU system was originally developed in Japan and transferred to Sunderland when the plant was opened. It was further developed and transferred back to Japan.	This is the only case study within this research where a technology was transferred from one site to another. Developed and transferred back.	The technology was embedded, developed and then transferred.

Table 4-3 Case study –NMUK (Continued below)

Source of technology	Transfer details	Impact
<p>PLASTIC MOULDING OF PETROL TANK IN ASSEMBLY LINE NMUK to Japan</p> <p>Following a waste reduction programme, it was recognised that the best place to site a plastic moulding machine for the petrol tank was actually in the assemble line. This is normally sited in a production area.</p>	The approach was adopted into one of the Japanese sites as proposed.	
<p>OPERATOR CARE PROGRAMME NMUK to Japan</p> <p>This is an approach to assess the operator environment relating to their wellbeing and ultimately reducing the amount of sickness and lost production. Although the obvious positive motivation exists through company care towards the employees, it is financially driven. Consideration is towards lifting, body twist, vibration, etc. The numerical assessment triggers a kaizen team on an improvement to the design of the work-station.</p>	At the time of writing, this approach was being considered for transfer into all Nissan factories world-wide.	
<p>WATER COOLING OF POWER PRESS TOOLING Japan to NMUK</p> <p>A form tool for producing car body components was introduced at NMUK. Similar tooling had been used in Japan and due to the increased temperatures experienced by the tool, cooling was necessary. The tool was produced in Japan to the same specification as those used in Japan. Unfortunately, the diameter of the holes through which the water was to flow were very small and took no account of the fact that the cooling water at the plant in Japan was far softer than the hard water supplied in the Sunderland plant. Consequently, after some months, the holes clogged up and the tool overheated and sustained severe damage. The solution has been to fit a visible flow meter on the tool and flush the cooling system on a regular basis</p>	Technology transferred without full knowledge of the environmental conditions of the host site.	Environmental

Table 4-3 Case study –NMUK

4.4.5 Summary of salient observations at NMUK

Similar to the summary of observations of the case studies within Rittal and ALSTOM Power, see sections 4.2.5 and 4.3.4 respectively, a summary of the content from the NMUK case study is listed below:

- **Influence from HQ – senior management.** Strong encouragement from the senior management at the headquarters for technologies to be shared and the directional trend of the business.
- **Initiator becomes transferor.** Where the person who suggested the transfer of the technology becomes the one who will carry out the transfer.

- **Intra-firm global competitiveness.** The necessity to maximise competitive competencies over sister manufacturing sites.
- **Development of the technology – continuous improvement.** The importance improving a technology after it has identified at a home site.
- **Time spent at home site by host transfer team.** Personnel and resources from the host site, necessary visit the home site to witness and learn the new technology.
- **Time spent at host site by home transfer team.** Personnel and resources from the home site, necessary to implement and nurture the new technology.
- **Natural environment.** Recognition of the influences on a technology from the natural environment at the host site.

4.5 Summary of observations from the case studies

This section will summarise the contributions made from each of the three case study sites.

Observation	ASFOG/Peter	NHUK
Observed by Initiator	Initiator becomes transferor	Influence from HQ – senior management
Natural environment	Influence from HQ – senior management	Initiator becomes transferor
Initiator becomes transferor	Documentation: Drawings, specification, etc.	Intra-firm global competitiveness
Belief of technology usefulness	Documentation: Standardised language and format	Development of the technology – continuous improvement
Time needed for embedding	Time spent at home site by host transfer team	Time spent at home site by host transfer team
Availability of home resources needed for embedding	Time spent at host site by home transfer team	Natural environment
Supplier infrastructure		
Modification of technology		
Strategic directional trend.		
Influence from HQ		
Natural environment		
Documentation: Drawings, specifications, etc.		
Communication links		

Table 4-4 Summary of salient observations during case studies

4.5.1 Common aspects

One of the common aspects which became evident in all three of the case study companies was the influence of the head office with regard to technology transfer in relation to global competition. This helps us to understand that technology transfer is not only an issue between the two sites involved with the transfer but that there is another dimension not previously included in technology transfer models and frameworks: The corporate environment. Categories affected within this environment include:

- Political restrictions
- The role of the initiator of the transfer
- Financial issues
- Access of the home site to the transferor.

These 4 elements within this category will form a fundamental dimension of the new framework.

4.6 Summary

This Chapter has reported the international technology transfer activities of three large manufacturing organisations and recorded the observations made. The case studies have provided a significant international contribution to the research highlighting areas not previously included in technology transfer models. The observations provide a ‘real use’ element to the development of the final framework, recognising the difficulties encountered by those involved in the case studies.

The following Chapter will consider current technology transfer models and contribution from other relevant literature. The Chapter will then go on to bring together a new framework which can be used as a foundation of a useable workbook.

CHAPTER FIVE DEVELOPMENT OF THE FRAMEWORK

5.1 Introduction

The explanation phase of Meredith et al's (1989) research cycle, this Chapter will develop a new pre-transfer assessment framework, bringing together:

- (i) Existing literature relating to technology transfer models and frameworks (Chapter 3).
- (ii) Observations made through the case studies (Chapter 4).
- (iii) Contributions from other relevant literature (Section 5.3).

Content from other literature includes: international cultural differences, communication issues, supply chain management, global competitiveness/international manufacturing networks, financial considerations and training.

The process of formulating such a framework will be to assimilate the information gathered from the academic literature (Chapter 3) along with the observations made during the action research and case studies (Chapter 4).

Figure 5-1 shows a diagrammatic representation of the development of the new framework. Using the generic model (see Figure 3-3) as the foundation of the framework and is the basis for the categorisation of the salient characteristics.

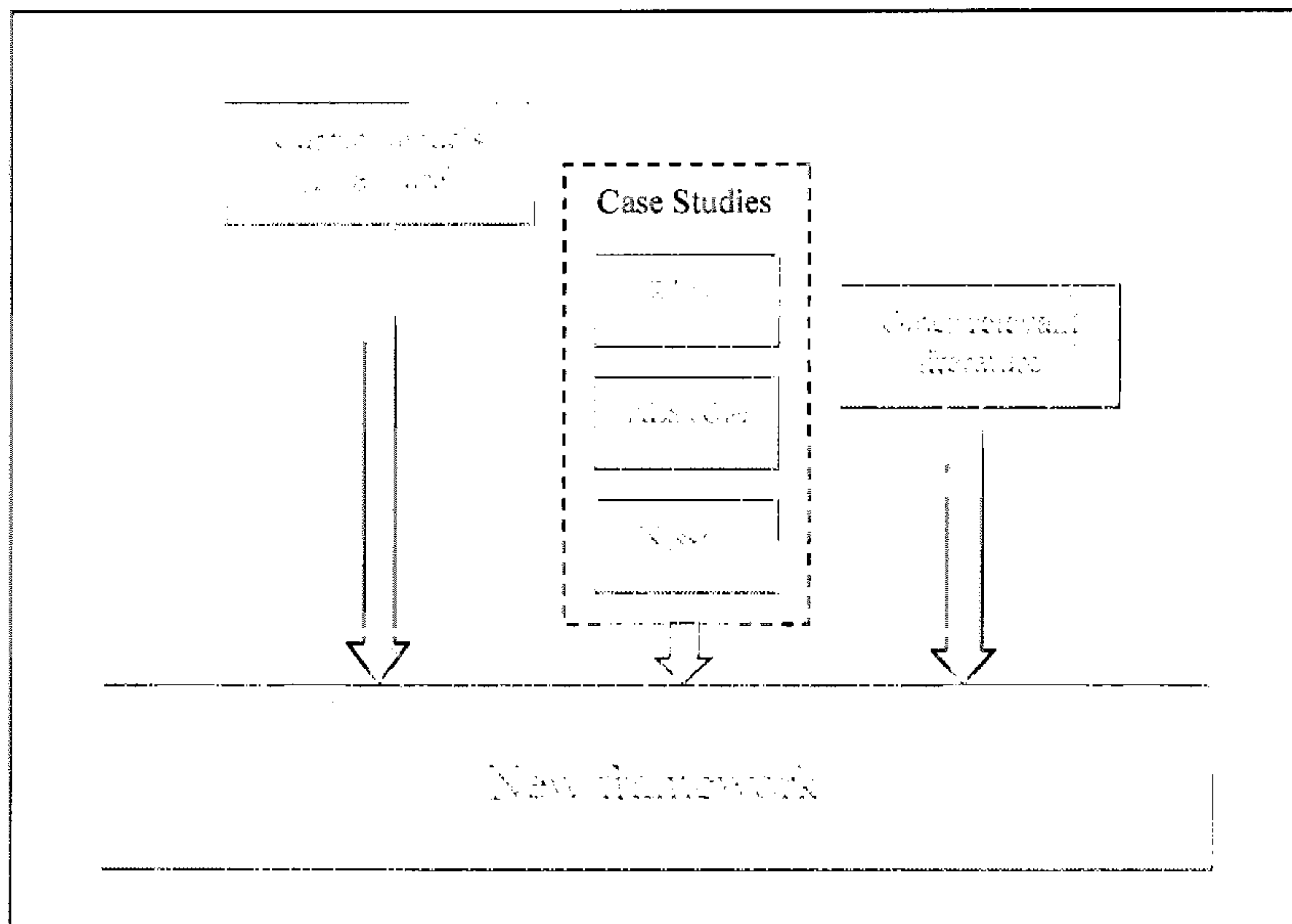


Figure 5-1 Diagrammatic representation of the development of the framework

The observations recorded from the case studies are then summarised and brought together into the new model. Finally, contributions from other relevant literature are considered towards the final framework.

5.2 Salient observations from current models and frameworks

This section will consider contributions from existing models and frameworks. Using the generic model as a foundation for the new framework, the content will be categorised against the components of the generic model.

5.2.1 Generic model as the foundation of aggregating existing models and frameworks

Figure 3-3, previously shown in Chapter 3, represents the generic model as described by Reddy and Zhao (1990), Keller and Chinta (1990), Tsang (1994), Mansfield (1974), Gungjan and Carne (1987) and Teece (1981a). The appropriateness of this model as a foundation to describe the entire process, is supported by Aharoni (1991) who along with Behrman and Wallender (1976) also propose interrelationships between the nature of the

technology, transfer process, and the characteristics and capabilities of the home and host site. Consequently, this will form the foundation of the framework being researched.

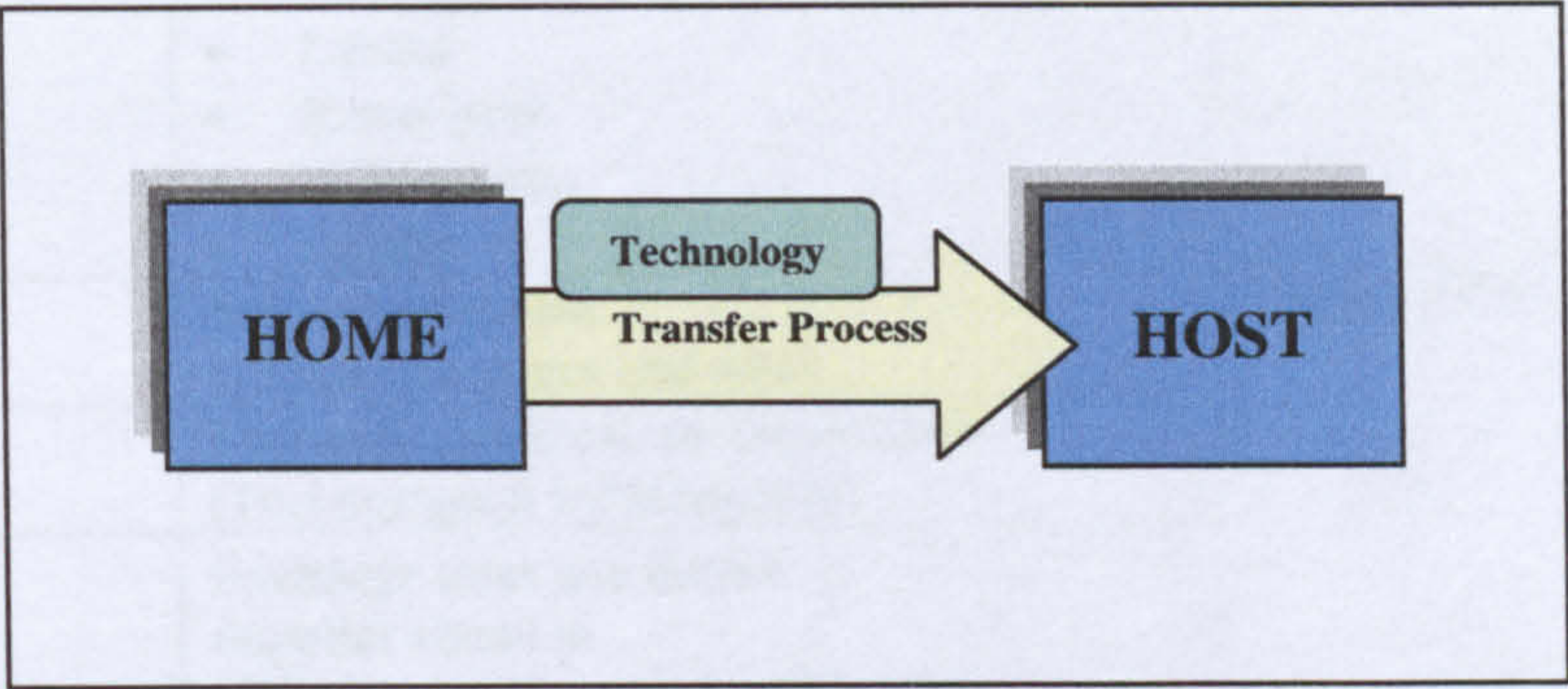


Figure 5-2 Generic Model (previously shown in Chapter 3)

5.2.2 Content of current models

Chapter 3 has demonstrated the existence of the significant amount of literature relating to technology transfer, the content of which has been tabulated in Table .5-2. The characteristics of the contributions are categorised in line with the generic model, Figure 5-2 (previously shown as Figure 3-3).

Category	Characteristic	Author
Home	Willingness/Co-operative spirit	Samli (1985), Chen (1996)
	Knowledge of the hosts background	
	Country of origin (Physical resources and cost)	Collet (1994)
	Facilities, Capacity, Technology	Steele et al (1997)
	Human Resources & Workforce Skills	
	Knowledge	
	Organisation Structure & Relationships	
	Fitness to transmit	Kedia and Bhagat (1988)
	Culture	
	Nature of participation	Lall (1980)
Transfer Process and Technology	Home caused barriers	Samli (1985)
	Host caused barriers	
	Complexity of technology	Lall (1980)

Table .5-1 Tabulation of existing technology transfer models/frameworks (continued below)

Category	Characteristics	Source
Samli (1985)	Needs	Samli (1985)
	Readiness	
	Background	Collet (1994)
	• Markets	
	• Raw materials	
	• Labour	
	• Know-how	
	• Willingness	
	• Ability	
	Site attractiveness (Human resources and cost)	Collet (1994)
	Economic, political, social situation (Technological infrastructure)	
	Exchange rates and duties Supplier situation (Transport, information and service infrastructure)	
	Facilities, Capacity, Technology	Steele et al (1997)
	Vertical integration & Material Supply	
	Human Resources & Workforce Skills	
	Knowledge	
	Organisation Structure & Relationships	
	Quality	
	External Environment	
	Fitness to receive	Kedia and Bhagat (1988)
	Culture	
	Nature of participation	Lall (1980)
Others	Aftermath (Assessment of the technology transfer.)	Samli (1985)
	Foreign Governments	Hemais (1995)
	Continuous Improvement (TQM approach)	Quazi and Bartles (1998)

Table .5-2 Tabulation of existing technology transfer models/frameworks

5.2.3 Aggregation of existing models

Table 5-3 below takes the characteristics in existing models and frameworks proposed by other authors, and aligns it with the key characteristics in the new framework.

Category	Characteristics in existing models/frameworks	Key attributes in new framework	Description
Home	Willingness	Co-operative spirit	Co-operative spirit within the home site transfer team/individual to carry out the technology transfer to the host site.
	Knowledge of the host's background	Experience of the home site	
	Country of origin	Cultural affects	
	Facilities, Capacity, Technology	Availability of home resources	Availability of the necessary home resources to undertake the technology transfer.
	Human Resources & Workforce Skills	Follow up support Availability of home resources	Planned visits for follow-up support Availability of the necessary home resources to undertake the technology transfer.
	Knowledge	Experience of the home site	Experience that the home site has with technology transfers.
	Organisation Structure & Relationships	Availability of home resources	Availability of the necessary home resources to undertake the technology transfer.
	Fitness to transmit	Experience of the home site	Experience that the home site has with technology transfers.
	Culture	International cultural differences	The effect of the international cultural differences between the home and host site.
	Nature of participation	Co-operative spirit	Co-operative spirit within the home site transfer team/individual to carry out the technology transfer to the host site?
Transfer Process and Technology	Home caused barriers	Documentation – drawings, procedures, specifications.	Availability of drawings procedures and specifications that will help the smooth transfer of the technology
	Host caused barriers	Documentation – drawings, procedures, specifications.	Availability of drawings procedures and specifications that will help the smooth transfer of the technology
	Complexity of technology	Alignment with current systems Modification to the technology Maturity of existing technologies	How well the technology in question complements other technologies at the host site The 'fit' of the technology in the format proven at the home site or does it need to be modified for the host. Have similar or complementary technologies been embedded and have they reached maturity to the extent that the host site is competent with their application?

Table 5-3 Characteristics from existing models/frameworks aligned with key attributes in new framework (Continued below)

Category	Characteristics in existing models/frameworks	Key attributes in new framework	Description
Host	Needs	Alignment with strategic needs	The amount that the technology complements the strategic needs of the business?
	Readiness	Existing technologies/ knowledge level	The where/when/ preparation to receive the technology.
	Background <ul style="list-style-type: none"> • Markets • Raw materials • Labour • Know-how • Willingness • Ability 	Modification to suit market changes Learning resources Willingness / Co-operative Spirit	The ability to modify the technology appropriately to suit changes in the market. The availability of the necessary competent personnel for sufficient time (possibly extended periods) to learn the technology being transferred. The host sites willingness and positive attitude towards the transfer and the receipt of the new technology into their site.
	Site attractiveness	Alignment with strategic needs	The amount that the technology complements the strategic needs of the business.
	Economic, political, social situation		Not applicable
	Exchange rates and duties	Financial benefits/support	The influence of exchange rates for investment and imported materials or processes
	Facilities, Capacity, Technology		Original host characteristics
	Vertical integration & Material Supply	Supplier capability	The infrastructure of suppliers to support a new technology.
	Human Resources & Workforce Skills	Learning resources Access to the transferor	The availability of the necessary personnel for sufficient time (possibly extended periods) to learn the technology being transferred. The access that the host site has to the transferor, and the ability for the transferor to visit the host site as required.
	Knowledge	Level of technical knowledge	The dependency on tacit or codified knowledge
	Organisation Structure & Relationships	Political restrictions	Influence of corporate politics.
	Quality	Existing technologies	Level competency on existing/similar technologies.
	External Environment	Environment	The effect that the host environment will have on the technology – humidity, road infrastructure, etc.
	Fitness to receive	Capability to receive	How experienced the host site is with receiving transfers.
	Culture	International cultural differences	The effect of the international cultural differences between the home and host site.
	Nature of participation	Co-operative spirit/ culture	

Table 5-3 Characteristics from existing models/frameworks aligned with key attributes in new framework (Continued below)

Category	Characteristics from existing models/frameworks	Key attributes in new framework	Description
Scholars	Continuous improvement	Corrective action loop	The host state's systems to correct anomalies and/or undertake continuous improvement.
	Foreign Governments		Not applicable
	Continuous improvement	Corrective action loop	The host state's systems to correct anomalies and/or undertake continuous improvement.

Table 5-3 Characteristics from existing models/frameworks aligned with key attributes in new framework

The aggregation of the salient content from existing models provides a suitable platform on which to build the new framework.

5.3 Observations from other relevant literature

The development of the new framework has started with the generic structural model, Figure 3-3, drawn from existing literature, section 4.3, and added to this observations made during case studies, section 4.4 and 4.5. This section will cover 7 important elements identified within other related literature which support the development of a more robust and thorough framework for international technology transfer.

- (i) Although Kedia and Bhagat (1988) focus their model around cultural issues, reported in section 3.6.1, and included in Table 5-3 (‘Characteristics from existing models/frameworks aligned with key attributes in new framework’), cultural issues have been significant in the case studies and therefore the subject warrants more investigation. Additionally, Slack et al (1998) highlight the general problems associated with cultural issues between Japanese and western people and, Lau and Ngo (2001) express concern relating to the parent company’s national cultural affects relating to overseas subsidiaries. When considering the transfer of

technology anywhere in the world, cultural issues is a significant element to be considered.

- (ii) The second subject being considered is that relating to redeployment strategies (sequential, parallel or delayed) as reported by Keller and Clark (1990), and the application against these of learning curve theory as presented by Adler and Clark (1991).
- (iii) Thirdly, communication issues are considered. Relating not only to difficulties involving foreign languages and terminology but also the complications regarding time differences and the unreliability of technology in lesser developed regions of the world. Finally, in regard to communication issues, the importance of face to face contact is discussed.
- (iv) Fourthly the complications involving global supply chain management are examined. This is particularly important where technologies are transferred internationally into regions whereby local infrastructures are inadequate.
- (v) The importance of strategic global competitiveness in relation to the design of manufacturing networks and the firm's capabilities is examined.
- (vi) Penultimately, financial implications are reviewed. Particular attention is given to authorisation of the necessary capital investment and payback or return that the investment will yield, recognising the firm's ability to finance a project in terms of cash flow.

- (vii) Finally, training is considered. As a critical element of the process, training of the host staff is crucial for the success of a new technology, including measurement of the starting point to enable objective assessment of the ultimate success of a project.

5.3.1 International cultural differences

Within their technology transfer model Kedia and Bhagat (1988) construct around the cultural characteristics of the home and host sites. The most well known (Carlson et al, 1996) and significant (Bhagat and McQuaid, 1982) works of investigation into international cultural differences was carried out by Hofstede (1991). Hofstede, categorised his findings of international cultural differences between the people of different countries across the world and compiled 4 major traits:

- **Power – Distance.** The extent to which power is distributed. Including, delegation of authority and consultative approach such as UK, Germany, Holland Denmark and Republic of Ireland or the centralised hierarchical structures preferred in France, Belgium and Portugal.
- **Individualism vs. Collectivism.** Self care and independence versus a tight knit framework of interdependence. Individualistic cultures favouring rewards on merit and a relationship based on mutual benefit such as UK, US, Holland and Denmark, compared with collectivist cultures such as Portugal, Greece, Southern Italy, most Asian, Pacific Rim and South American countries where employees expect the company to look after them in exchange for loyalty.
- **Masculine-Feminine.** Macho cultures such as UK, US, Austria, Italy, Japan and Switzerland with assertive, performance driven individuals compared with Scandinavia

and the Netherlands where people value more feminine traits such as caring for others and quality of life.

- **Uncertainty Avoidance.** How far the people feel threatened by uncertainty and ambiguity. French, Belgians, Spanish, Portuguese and Germans need rules and a formal structure to feel secure, whereas countries like UK, Republic of Ireland, Denmark and Sweden are comfortable with flexibility and accepting dissent.

These observations made by Hofstede give an excellent pre-warning of cultural differences. The author has observed significant different cultural differences during the action research:

- British – German
- British – Indian
- British – American
- German – Indian
- German – American

Although the Indian/American combination is obviously possible, the author has never been involved within a transfer process including the two different cultures together.

A detailed analysis of the observations is outside the scope of this work and the author does not feel qualified to give any further critique other than to report the fact that certain cultural traits have sometimes made working in some of these environments extremely difficult and tense.

Within the subject of international cultural differences the relationship between the head office and the daughter site is also recognised. In particular, Lau & Ngo (2001) report on the affects that the parent company's own national culture can have on the operational and management practices of the subsidiary sites. They go on to say that too often, heavy handed responses from headquarters squelch local enthusiasm and drive out good ideas – and good people. Optimistic thinking may be that successful corporate executives recognise that good ideas can come from any foreign subsidiary but the reality of this may be less often than hoped for.

5.3.2 Transfer sequences

There are a number of possible sequences of transferring a proven technology from one site to others each of which can help to resolve problems that cause difficulties during transfers. An organisation that becomes more adept at pre-empting or resolving transfer related problems will be better prepared the next time that a transfer occurs.

The financial benefits, or cost savings, of adopting a proven technology has been the subject of much interest, see: Schonberger (1986), O'Dell et al (1998), and clearly as the technology becomes fully adopted and embedded the financial benefits gained from the introduction of the technology will increase.

In the case of intra-firm technology transfer, which Buckley, (1988) terms 'internalisation', redeployment strategies for existing products or processes can be implemented in a sequential, parallel or delayed manner (Keller and Chinta, 1990).

In a sequential transfer the technology is only transferred to another site after the technology has been proven at the home site. Although not the subject of this thesis, in

cases where the technology in question is ‘the manufacture of a product’, transfer may not take place until after it has completed its life cycle in the home site first (Vernon, 1966). In a parallel transfer situation the technology supplier simultaneously introduces the new technology into all sites at the same time. In a delayed situation, a new technology is first introduced at the home site, later after experience is gained and improvement made, the technology is transferred to another site. Considerations can then be given as to whether it is more beneficial to transfer in the sequential or parallel method.

To graphically present, Keller and Chinta’s (1990) 3 categories of transfer sequence, a theoretical global manufacturer having 5 MNEs is shown in Figure 5-3 demonstrating the options.

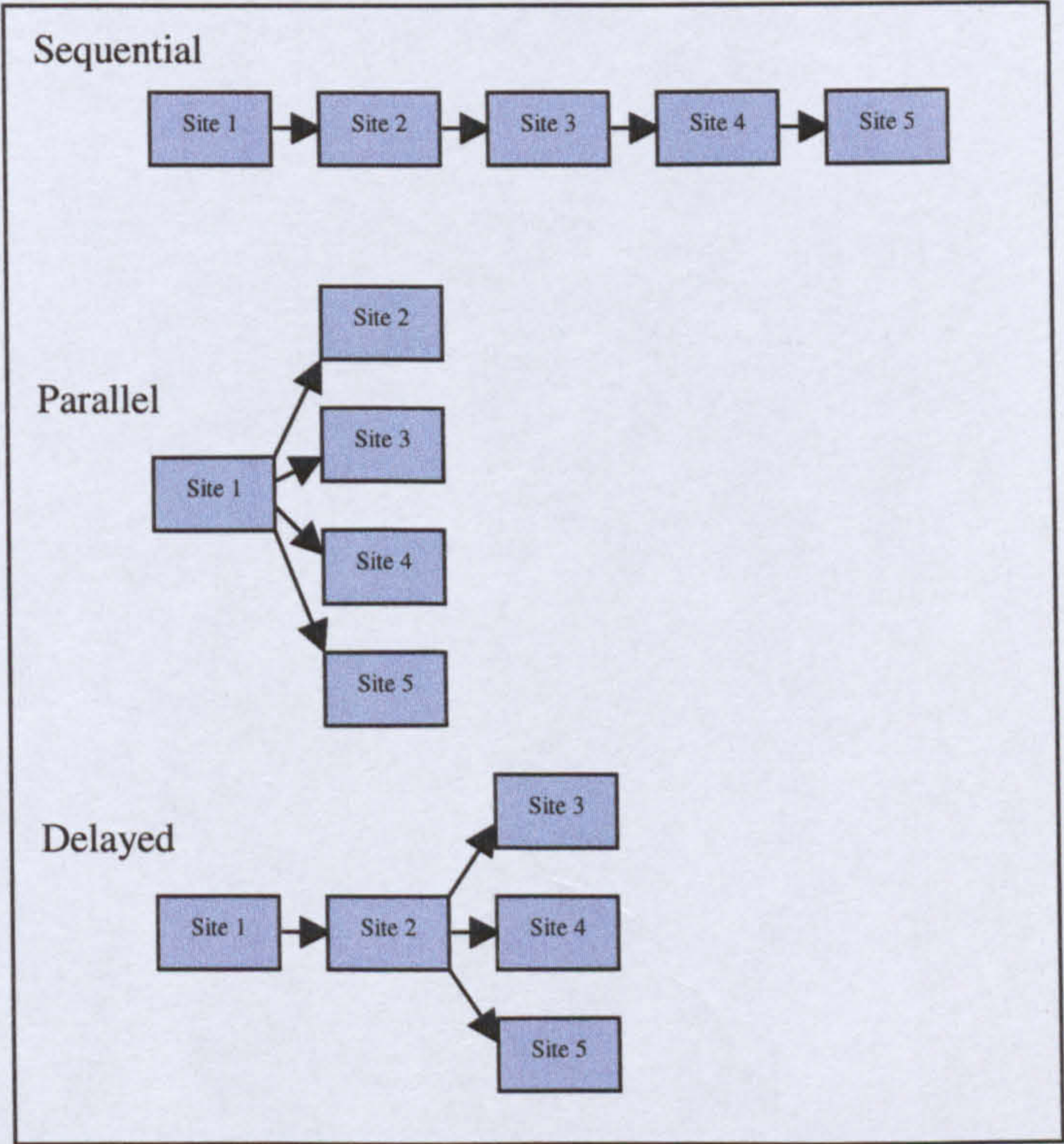


Figure 5-3 Representation of transfer sequences – based on Keller and Chinta (1990)

With this in mind, consideration can be given the appropriateness of Adler and Clark’s (1991) recognition of learning curve theory applied to technology transfer. The benefit of

the learning curve in the context of technology transfer has been recognised by Keller and Chinta (1990) but the theory has not generally been exploited.

The principle of learning curves was first presented as a theory by T. P. Wright in 1936 and was developed principally in the manufacture of aircraft to predict overall production costs over volume projects (Lundberg, 1956). The traditional application of learning curves is to plot operation costs against quantity. As the quantity increases, the operation costs decrease. The reduced cycle time/operation times are achieved through familiarity with the operation and improvements in methods, (Adler and Clarke, 1991) although, Womack et al (1990) suggest that reductions can also occur as a result of Kaizen projects.

In the sequential (or series) scenario, with the above in mind, one would expect the cost of implementation to be less for the last one than it would be for the second, for instance. See Figure 5-4. However, the financial benefits gained from the introduction of the technology would not be enjoyed until much later. Depending of course on the time-scale of the implementations. Nevertheless, Szulanski and Winter (2002) argue that when following the 'copying exact from a template' approach, it is possible to reduce the learning curve by several months.

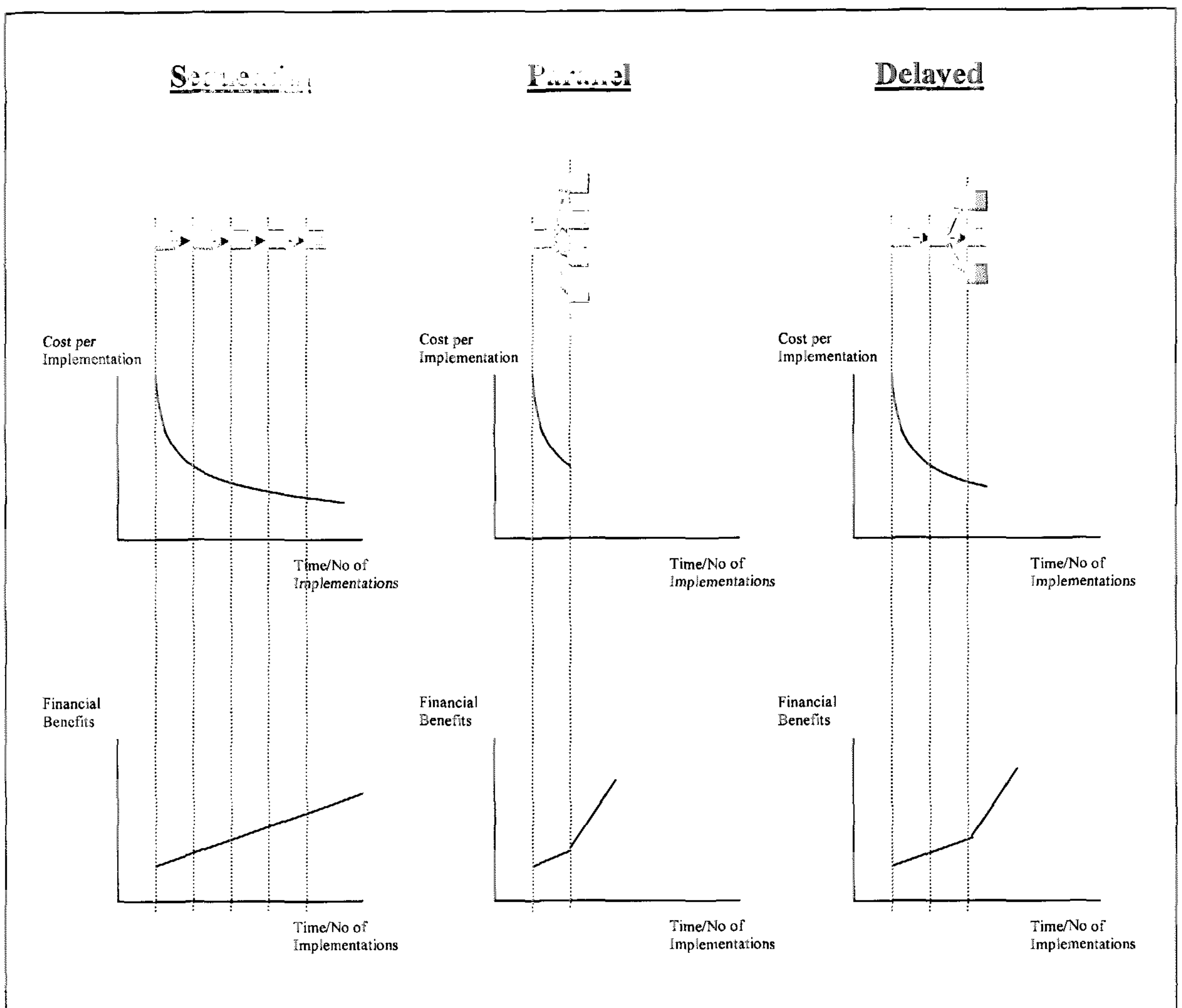


Figure 5-4 Representation of learning curve theory applied to sequential technology transfer

However, when the 'Parallel' or 'Delayed' scenarios are considered, this approach becomes far more complicated due to the fact that the cost of implementation will decrease due to the lost 'learning' effect of the implementor/implementation team. The implementor will be less experienced in the implementation of the technology and there will be little knowledge gained from the problems encountered on the pilot project. Compounding this situation is the potential financial benefits which can be gained earlier in the time-scale than in the sequential scenario.

In summary, the project manager or implementor is faced with 2 conflicting options:

1. The sequential approach – which reduces the cost of implementation as the number of implementations increase.

2. The financial gains – from the use of the technology more sites will benefit earlier if they receive the technology straight away.

Bringing together the costs and benefit, it is easy to see that the possibilities become very complex. To help understand the situation the financial benefits can be considered, against the cost of implementation (learning curve) Figure 5-4, presenting them together in the form of a 2 x 2 matrix – Figure 5-5. Clearly the implementation costs will be higher if the host site is early in the sequence.

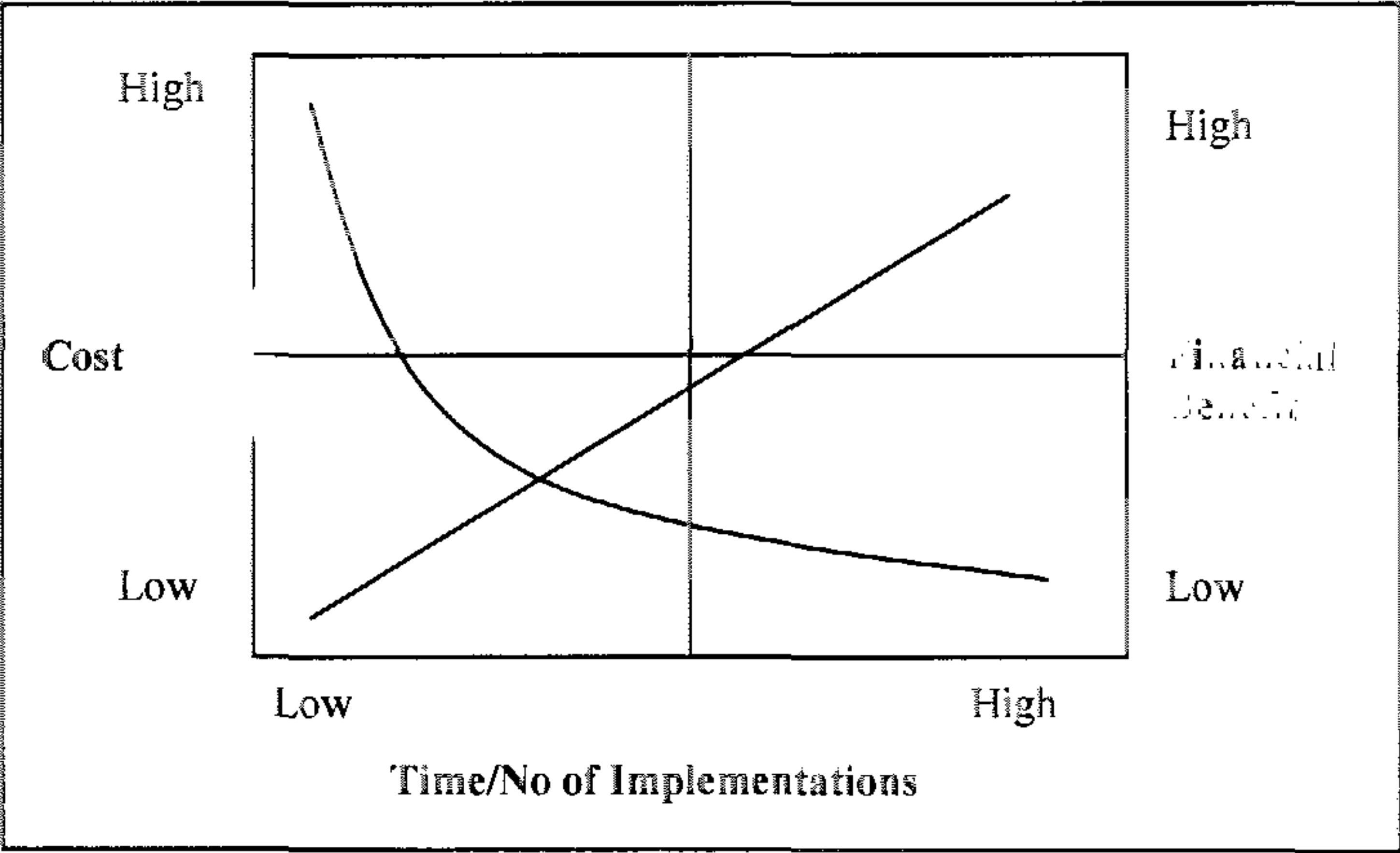


Figure 5-5 Cost/Financial benefits matrix

5.3.3 Communication issues

In reporting the development of computer technology between the 1930’s and 1960’s, Tweeddale (1992) covers the following aspects of technology transfer:

- USA was able to exploit British ideas through available finances.
- The interactions between both parties were complex.
- The speed of the transfer of computing technology for its development was due to a number of factors:
 - A common military cause. This view on teamworking is also supported by Leavitt (1972) who terms the truism for teamworking as identifying a common enemy.
 - Both parties spoke the same everyday language.

- Both parties spoke the same scientific language.
- Information could be passed swiftly and freely between interested parties, there were no restrictions - political or otherwise.

In the context of technology transfer Tweeddale (1992) contrasts everyday and scientific language. The author's action research has revealed that the ability to communicate in everyday language alone is not sufficient to ensure successful transfers of technology. Communication breaks down eventually (rather than quickly) when neither party clearly understands the technical elements behind the technology.

5.3.3.1 International engineering terminology

Within the international technology transfer environment, there are fundamental differences which cause difficulties and confusion. Typically, terminology used in one country is not the same as that in another to describe exactly the same thing. Two examples which have been noted during the research are:

1. Within the UK, the character used to define the start of a decimal is a decimal point and the character used to define multiples of three 0s is the comma. However, in Germany, the use of these characters is exactly opposite. That is: in UK one would write 465,767.379 but, the same number would be written as 465.767,379 in Germany. Whilst the difference in convention is unlikely to cause too many errors as a dimension – providing a modicum of common sense is used – numbers of purchased parts can easily be mistaken.
2. The convention for describing the physical size of an electrical or electronic cabinet in the USA is '*depth/height/width*', throughout the rest of the world it is '*width/height/depth*'. This causes problems because within the industry, individuals

rarely describe an enclosure as for example 600mm wide x 2000mm high x 800mm deep. It is normally 600 x 2000 x 800. Consequently, without the prior knowledge of different conventions, mistakes are easily made. Compounding the confusion, most manufactures design their product article numbers around the convention. For example: a Rittal PS 4608 enclosure produced in Germany is exactly the same product as a PS 4806 produced in USA.

Within the realms of practicality, there is little anyone can do to change the above difficulties. Proposals have been made to change the use of the decimal point and the comma within the UK (see BS 8888) to align UK engineering practices with that of the continent. However, this has received tremendous objections from many engineering professionals⁶ and like the changes from the imperial system to metric – it will probably take a long time. Regarding USA changing their convention of describing electrical and electronic enclosures to that of the rest of the world, this is highly unlikely. Their attraction to the imperial measurement system is extremely strong with almost no sign of giving up the use of ‘Fahrenheit, inches, pounds, etc.’ consequently there is little expectation of change within the enclosure industry.

As with the foreign languages, these conventions are practices which currently have to be learned and care has to be taken. Mistakes are easily made and the consequences are often costly, particularly when a customer in USA receives a container full of perfectly well made product made in Germany, only to find that it is not what they wanted.

⁶ See ‘Professional Engineer’ Volume 13 Number 18

5.3.3.2 Face to face contact

The need to communicate clearly and quickly creates a pressure to codify what might otherwise remain tacit knowledge. Yet the very act of codification sheds tacit knowledge (Polanyi, 1966). This stays behind with the transmitter who consciously or unconsciously always knows more than he/she can ever say. An act of communication is therefore always, in some fundamental sense incomplete (Boisot, 1995).

Teece (1981a) emphasises the importance of face to face contact when transferring technologies, as a significant amount of the know-how (which is needed to make the technology transfer work) is carried in people's heads. Chen (1996) refers to trust and co-operative spirit being indispensable for technology transfer agreements to be viable in the long run.

Wang (1994) explains that, in China between 1992 and 1993, over 7800 technical personnel were transferred abroad for continued training and over 2000 foreign experts in the field of technical engineering education were invited to universities in China. The latter approach was considered to be more beneficial on economic grounds.

These views are also supported by evidence from the author's action research and case studies whereby those involved do not only have the opportunity to ask questions but they also build up a rapport and feel more trust towards each other.

5.3.4 Supply chain

Many authors have expressed the importance of reliable material suppliers and supply chain management in the context of competitive performance (Laming, 1993; Moody,

1993; Hines, 1994). However, the difficulties facing an MNE in foreign locations are more far reaching.

Whilst this work does not intend to critique all of the issues relating to international supply chain management, the author does however, refer to the work of Thérèse Flaherty (1996) who dedicates a substantial portion of her book on global operations management to global supply chain performance. Flaherty highlights many of the issues associated with a supply chain in the context of MNEs which are broadly divided into 2 categories (Table 5-4) which the MNE must consider:

Supply from international vendors	Supply from local vendors
<ul style="list-style-type: none">• Transportation difficulties (weather, etc.)	<ul style="list-style-type: none">• Existence of suitable vendors locally
<ul style="list-style-type: none">• Exchange rates	<ul style="list-style-type: none">• Cultural issues
<ul style="list-style-type: none">• Import duties	<ul style="list-style-type: none">• Natural resources
<ul style="list-style-type: none">• Delivery times	<ul style="list-style-type: none">• Supply networks
<ul style="list-style-type: none">• Adjustment to schedules	<ul style="list-style-type: none">• Transport infrastructure
<ul style="list-style-type: none">• Total landed cost	<ul style="list-style-type: none">• Quality understanding
<ul style="list-style-type: none">• Inventory in pipeline and safety stock	<ul style="list-style-type: none">• Sensitivity to problem solving
<ul style="list-style-type: none">• Co-ordination	

Table 5-4 Difficulties MNEs face with supply chain management (based on Flaherty 1996)

The table is clearly not exhaustive but gives the reader an overview of the difficulties which must be considered when transferring a technology to another location.

5.3.5 Global competitiveness International manufacturing networks

The growth of global manufacturing has increased dramatically over the past 100 years and exponentially over the past 30 years. An indicator of the development of global manufacturing is the amount of foreign direct investment (FDI), which in 1971 was US\$172.1bn and increased by a factor of 9.4 by 1990 to US\$1613bn. With the industrial

development of the Pacific-rim countries, Mexico, Brazil, India, etc. Many western companies are drawn into the environment, Freeman (1996).

From a strategic standpoint, Shi and Gregory (1998) propose that a network should be designed to exploit a firm's competitive capabilities. They suggest a framework for 'capabilities network configurations' whereby a capability map or profile can be produced to assess the global network capability of the firm. MNEs and their international manufacturing systems can then become the main engines for their global economic growth. Supporting the importance of international networks, Lau and Ngo (2001) argue that a critical success factor for technology transfer is typically how well the project champion is connected with other parts of the corporation.

The global environment is one whose importance is increasing year by year and one which is attracting attention for strategic management and development of networking. Furthermore it is an important characteristic relating to international technology transfer which is a dimension not included in any existing models.

5.3.6 Financial considerations

To achieve any technology transfer will require some financial investment. Whether it is tangible such as machinery and equipment or intangible such as knowledge and experience. The following 3 sections examine the financial facet of international technology transfer and how it can affect the decision making and difficulties during the technology transfer process.

5.3.6.1 Investment

Bierman and Smidt (1986) define investment as “the commitment of resources made in the hope of realising benefits that are expected to occur over a reasonably long period of time in the future”. Similarly, Sharpe et al (1999) define it as “the sacrifice of current cash for future cash ... with two different attributes involved: time and risk”. In view of the ‘time and risk’ attributes, the length of time and size of risk will be part of the decision making process along with available finances to fund the investment (Bierman and Smidt, 1986; Sharpe et al, 1999; Levey and Sarnat, 1994).

5.3.6.2 Payback

The principles of finance can be traced back to the old Babylonian period (circa 1800 – 1600 B.C.) in Mesopotamia (Levey and Sarnat, 1994). However, even up to modern times, the decision making process businessmen still use is the non-discounted rules of thumb such as simple payback formula as opposed to the more ‘complex time-discounted’ decision rules or even the ‘accounting rate of return’ (Levey and Sarnat, 1994). However, whichever method is used to decide if a project should receive investment approval or not, the following points should be considered:

5.3.6.3 Main characteristics

The list presented below is a summary of terms and definitions of the main characteristics relating to capital investment proposed by: Harvey and Nettleton (1983), Bierman and Smidt (1986), Sharpe et al (1999), French (1985) and Levey and Sarnat (1994):

1. **Payback** (Amortisation). The payback period which will attract the necessary funding, (no matter how it is wrapped up), will be a function of the following:

1.1. Time. The period over which the benefits of the investment will equal the investment itself.

1.2. Risk. The amount of risk a company is willing to take in order to pursue the anticipated benefit.

2. Return (Financial benefits). The amount of cash received as a result of the investment, usually considered over a one year period after the investment has stabilised. It should be noted that a clear financial return is often difficult to calculate such as training, or the benefits of technologies in order to develop flexibility. The necessity to become more flexible could be simply due to market changes or demands and consequently the risk element of the decision making increases.

3. Cash-flow (Available finances). The difference between total cash inflows and total cash outflows of an accounting entity over a period (or of an investment project).

4. Investment approval. The level within an organisation at which authorisation approval may be given for a particular investment sum.

5.3.7 Training

Having identified the suitability of a technology to be transferred to another site, questions arise about training.

1. Who will be trained?
2. Who will carry out the training?
3. How will it be delivered?
4. Where will it be delivered?
5. How will one know if it has been successful?

The fundamental objective of any training is to increase the effectiveness in part of the organisation. Whilst answers to the first 4 questions above may well be inevitable due to unavoidable circumstances at the home and host sites, the question of training effectiveness is one which must be considered. Goldstein (1993) suggests that systematic evaluation of the effectiveness is necessary to make competent decisions relating to the instructional activities.

Traditionally the overall training process will cover all steps from identifying the need through to revising the content or training method. Bramley (1996) proposes a ‘systematic training cycle’ and presents this in 5 overall steps, see Figure 5-6. This certainly encompasses the activities surrounding the evaluation stage, and supports Goldstein’s (1993) recommendation of its importance.

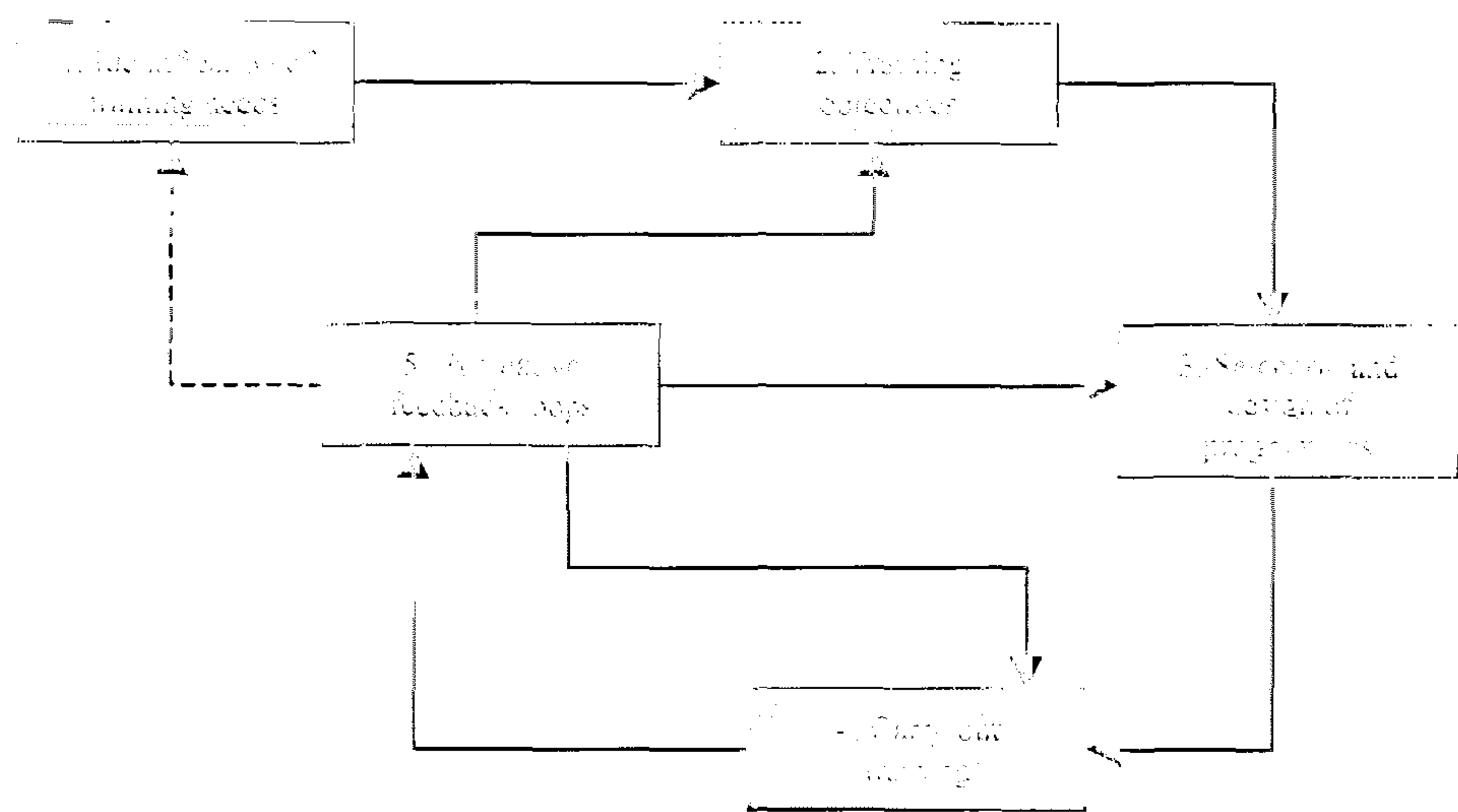


Figure 5-6 Systematic training cycle, Bramley 1996

During the case study interviews at NMUK it was revealed that they have a particularly well structured training organisation with procedures in place to cope with the introduction of new technologies, etc. even new models of a motor car. Separate areas are set aside and programs exist which allow for personnel to be removed from their normal duties for

training activities. This is achieved by budgeting an extra 7% in the manpower head count which is intended to account for all training activities throughout the year.

However, not all organisations have the business structures in place to provide such facilities. This is particularly the case where the manufacturing plant is in lesser developed countries where the plant is still in the phase of establishing itself and trying to keep costs to a minimum. At the Rittal India plant in Bangalore, there is certainly no training department but the management are encouraged train the employees not only to set and operate the equipment but also to adopt the Nissan principle of every man/woman being able to carry out 3 tasks and each task having 3 men/women trained. As new technologies arrive at the plant, time spent on training is either recovered through overtime, or temporary labour is recruited to bridge the gap.

It is clear that to adopt a new technology training is required. It is important that in the pre-transfer assessment phase of the process, the assessor recognises that training will have to be accounted for and arrangements made to carry it out.

5.3.7.1 Measurement of success

Having accepted that a technology is to be transferred and that a training program is in place, the question now arises “How will one know if it is successful?”

The obvious point here is that before one can know how successful an activity has been, the following need to be known (Bramley, 1996):

1. What was the status before implementation.
2. What was the status after it was complete.

With a similar view on metrics, Kerzner (1998) defines project success in terms of meeting 3 objectives:

1. Completed on time.
2. Completed within budget.
3. Completed at the desired level of quality. (Quality meaning meeting technical specification).

These points are internal to the project, and do not include performance to the user or the customer. However, Tukel and Rom (2001) propose that the real 'quality' measure of success of a project (and should be included in the specification) is a higher focus on the end user.

However, before evaluation can be meaningful, the decision needs to be made over *what* is going to be measured? As Bramley (1996) points out, measurements must be aligned to goals and objectives.

It is evident that during the pre-transfer assessment stage, the assessor recognises the objectives and goals which the technology are expected to achieve, and that measurements are taken prior to the implementation taking place. This will enable measurements to be taken later and the level of success judged.

5.3.7.2 Pilot project

Often deficiencies exist which will not surface until the implementation process begins. For this reason a small-scale tryout has many benefits, Hutchins (1999).

1. A pilot project will not stretch resources and ensure first efforts are well supported.

- 2. Individuals are less likely to resist a small-scale pilot project.
- 3. It can be modified as problems are highlighted, large-scale initiatives are far less easy to control.
- 4. A small-scale pilot enables the implementation team to demonstrate success of the technology.

5.3.8 Summary of relevant literature

Summarising the content from the review of relevant literature, Table 5-5 presents an alignment of the characteristic with the appropriate category for the new framework.

Characteristic	Author	Comments	Category
Learning Curve	Various	See section 4.5.2	Home
Training Requirements and Methods	Bramley (1996)		Host
Pilot Project	Hutchins (1999)		Host
Measurement of Starting Point	Bramley (1996)		Host
Everyday Language	Tweedale (1992)		Transfer Process
Technical Language	Tweedale (1992)		Transfer Process
Level of Technological Knowledge	Bohn (1994)	See section 3.5.2	Technology
Financial Benefits	Bierman and Smidt (1986), Sharpe et al (1999), Levey and Sarnat (1986)	Return on investment	Corporate Environment/ Home/ Host
Investment Approval		Level within the organisation	
Available Finances		Cash flow	
Amortisation		Payback period	
Review – Manufacturing Strategy	Hayes and Wheelwright (1984), Skinner (1985), Hill (1985).		Global Market Environment
Supplier Infrastructure	Flaherty (1996)		Host
Global competitiveness	Flaherty (1996), Shi and Gregory (1998)		Global Market Environment

Table 5-5 Content from relevant literature

5.4 Formulation of the new framework

Table 5-3 shows an aggregation of the content of existing models of technology transfer but still falls short of providing a useable framework for project assessment.

The proposed new framework includes the content from Table 5-3 along with the salient observations from the case studies and relevant literature. Apart from the relevance towards the type of technology being investigated, the proposed framework also takes into

account the complexity of multiple manufacturing sites from within a multinational enterprise.

Table 5-6, Table 5-7 and Table 5-8 below, bring together the content of current literature, case studies and relevant literature. The elements will form the basis of the new framework. The foundation of the framework is based on three environments:

1. *Intra multinational enterprise environment.* The environment between the manufacturing sites. (i) Home, (ii) Transfer Process and Technology (iii) Host. (Table 5-6)
2. *Corporate environment.* The environment within which the manufacturing sites lie and have to operate under the influence of their headquarters. (Table 5-7)
3. *Global market environment.* The environment within which the group or corporation perform against their competition. (Table 5-8)

The tabulation of the first of the three environments is presented below.

Current literature	Case studies	Relevant literature	Description in the New Framework
Home			
Availability of home resources	Availability of home resources needed for embedding		Availability of home resources
	Time spent at host site by home transfer team		
Experience of the home site			Experience of the home site
Co-operative spirit	Belief of technology usefulness		Co-operative spirit
		Training Requirements and Methods	Training Requirements and Methods
Follow up support			Follow up support
		Learning Curve	Learning Curve

Table 5-6 Tabulation of the elements of the new framework – Intra-MNE environment
(continued below)

Case studies		Reference literature	Existing framework
Transfer of technology			
Alignment with current system			Alignment with current system
Modification to the technology	Modification to technology		Modification to technology
Documentation – drawings, procedures, specifications.	Documentation: Drawings, specifications, etc.		Documentation – drawings, specifications, etc.
Availability of existing technologies			Availability of existing technologies
		Pilot Project	Pilot Project
	Documentation: Standardised language and notation		Everyday Language
			Technical Language
	Communication links		Communication links
		Level of technical knowledge	Level of technical knowledge
Host			
Willingness / Co-operative Spirit			Willingness / Co-operative Spirit
International cultural differences			International cultural differences
	Timeliness, Cutbacks		Timeliness, Cutbacks
Capability to receive			Capability to receive
Corrective action loop	Development of the technology – continuous improvement		Corrective action loop
		Measurement of Starting Point	Measurement of Starting Point
		Location of application	Location of application
Learning resources, access to the transferor environment	Time spent at home site by host transfer team		Learning resources
	Natural environment		Environment
		Supporter infrastructure	Supporter infrastructure

Table 5-6 Tabulation of the elements of the new framework – Intra MNE environment

Based on the generic model (Figure 5-2), the content of Table 5-6 is shown graphically in Figure 5-7 and forms the core of the new framework.

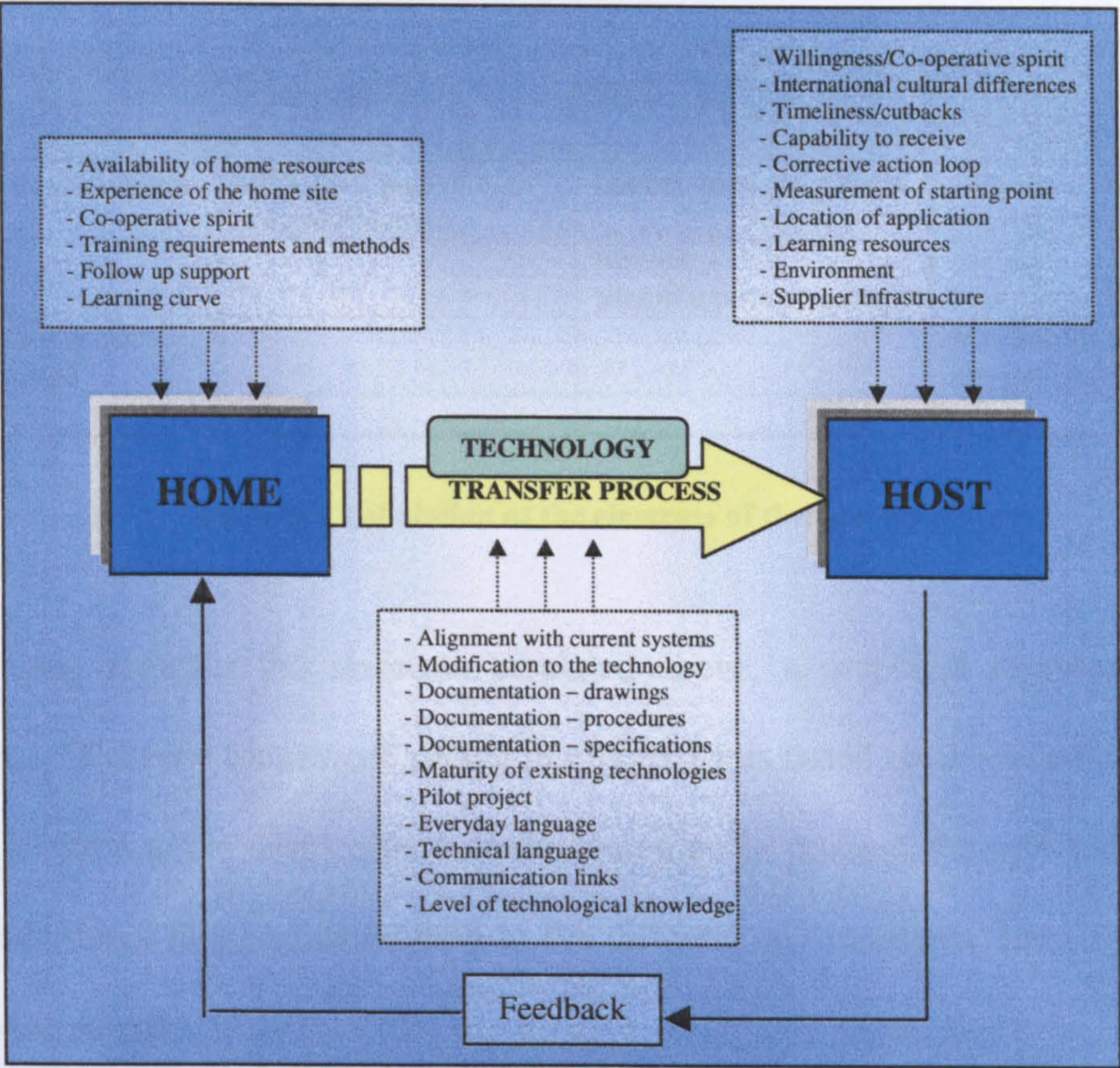


Figure 5-7 Intra MNE Environment

Building around the MNE environment 2 new environments are introduced. Table 5-7 shows the content within the corporate environment and Table 5-8 shows the content within the global environment.

Current literature	Case studies	Relevant literature	Description in the New Framework
	Influence from HQ – senior management		Political Restrictions
	Strategic directional trend. Influence from HQ		
	Initiator: - Observer - Initiator		Initiator
		Financial Benefits	Financial Benefits
		Investment Approval	Investment Approval
		Available Finances	Available Finances
		Amortisation	Amortisation
	Access to the transferor		Access to the transferor

Table 5-7 Tabulation of the elements of the new framework - Corporate environment

Current literature	Case studies	Implemented literature	Description of New Framework
Global competitiveness	intra-firm global competitiveness	Global competitiveness	Alignment with strategic needs
		Review – Manufacturing Strategy	Review – Manufacturing Strategy
Modification to suit market change			Modification to suit market change

Table 5-8 Tabulation of the elements of the new framework

By bringing together the elements tabulated above, a graphical representation can be presented. The new framework shown in Figure 5-8 is based on the generic model, Figure 3-3, in addition to the direct effects on the core transfer process, the new framework brings in the additional dimensions relating to the different environments; Intra-MNE, corporate and global market.

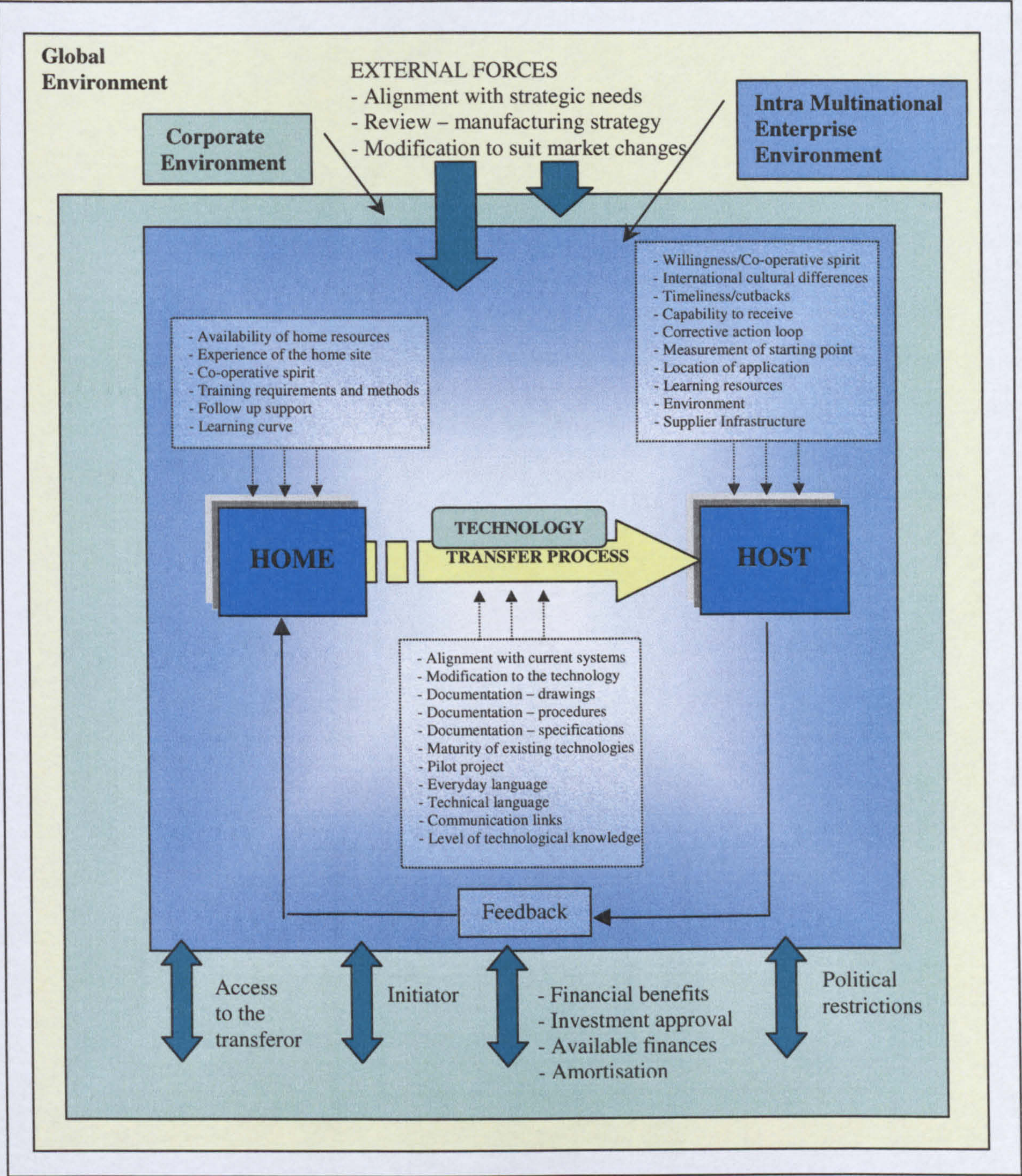


Figure 5-8 New framework

This is a new framework and is the author’s contribution to knowledge. It takes the issues of international technology transfer further than any existing models or frameworks and enables practitioners to assess potential difficulties prior to transfer. To assist practitioners with the use of the framework, and to enable practical validation of the proposal, a workbook has been developed.

5.5 Workbook

The justification for this research was to develop a pre-transfer assessment framework to aid those involved with international technology transfer. To make use of the developed framework, it will be form the basis of a ‘workbook’. The workbook, see Appendix 1, is constructed in three major sections:

1. **Guidelines.** Describing the salient components of the pre-transfer assessment including the pre-transfer assessment framework on which the whole assessment is based.
2. **Questionnaire.** A series of questions which the assessor answers, rating the degree of difficulty for each element of the technology transfer process. The assessor considers the obstacles within the intra-MNE, corporate and external environments, which may hinder the success of the transfer.
3. **Degree of Difficulty Chart.** A pull-out sheet to chart the rated degrees of difficulty assessed in section 2. This will give a visual representation of the overall difficulties facing the transferor.

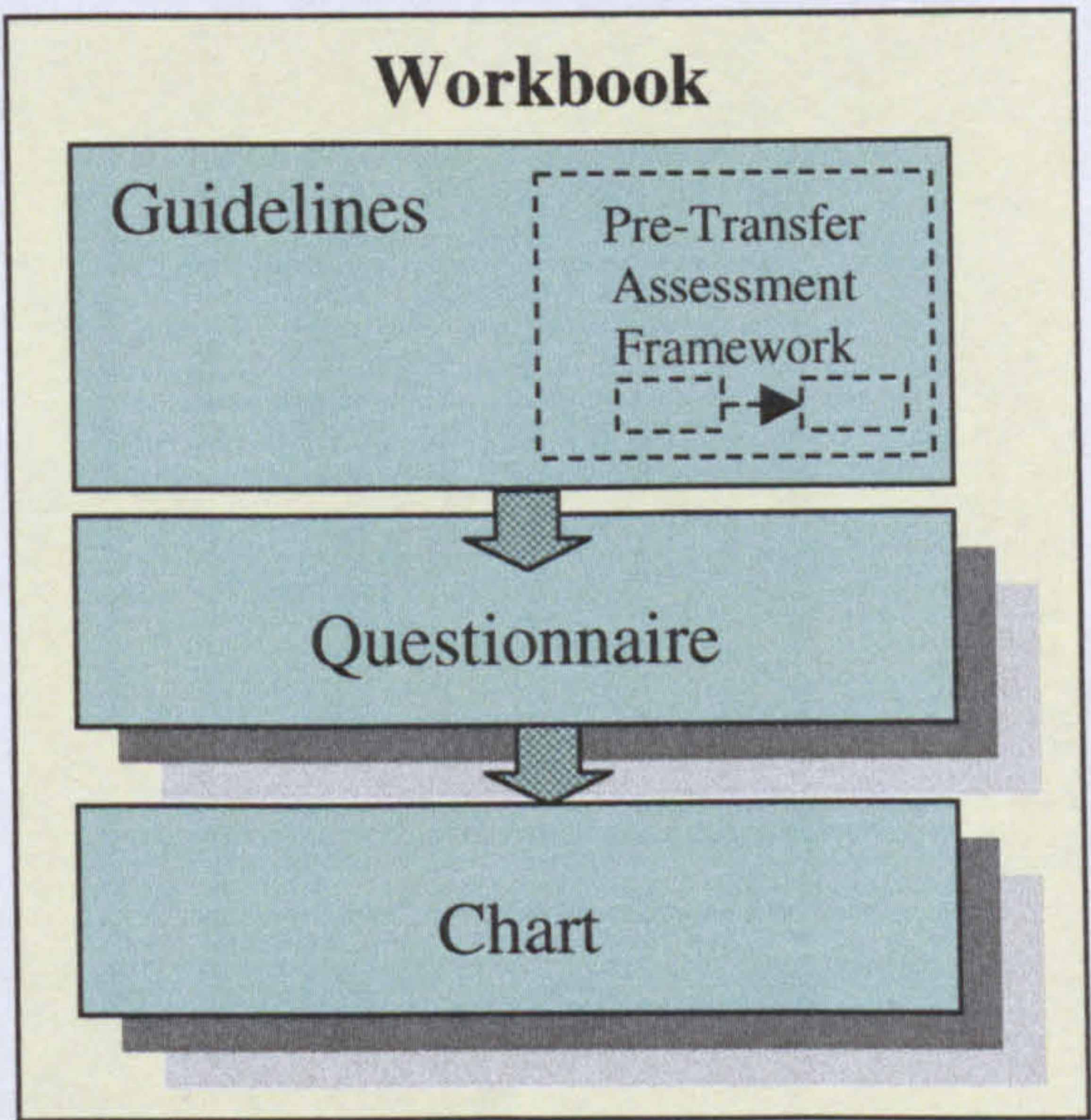


Figure 5-9 Overview of the Workbook

To enable the assessor to create a visual representation of the difficulties ahead, an indicator rating is used. The guidelines below suggest a rating that can be used. Please note that the assessment is rating the degree of DIFFICULTY. The rating indicators below are for guidance only.

Proposed rating of difficulty:

- Where the conditions being assessed would yield such answers as No, Poor, Difficult, Bad, etc. The assessor should score high, e.g. 9 or 10.
- Where the conditions being assessed would yield such answers as Yes, Good, Easy, Straightforward, etc. The assessor should score low, e.g. 1 or 2.
- Where the assessor feels that the answer should be somewhere in between then clearly an appropriate score should reflect the assessed situation.

Following the assessment of each section, the ‘Score’ should be transferred to the ‘Degree of Difficulty Chart’, similar to the example shown below (see Figure 5-10). This will provide the assessor with the visual representation of the problem areas.

Example: The table below, Figure 5-10, is an example of Section 2.1 of the assessment framework and demonstrates how the framework should be filled in. Here, the assessor has judged that the co-operative spirit and training are forecast as being problem areas.

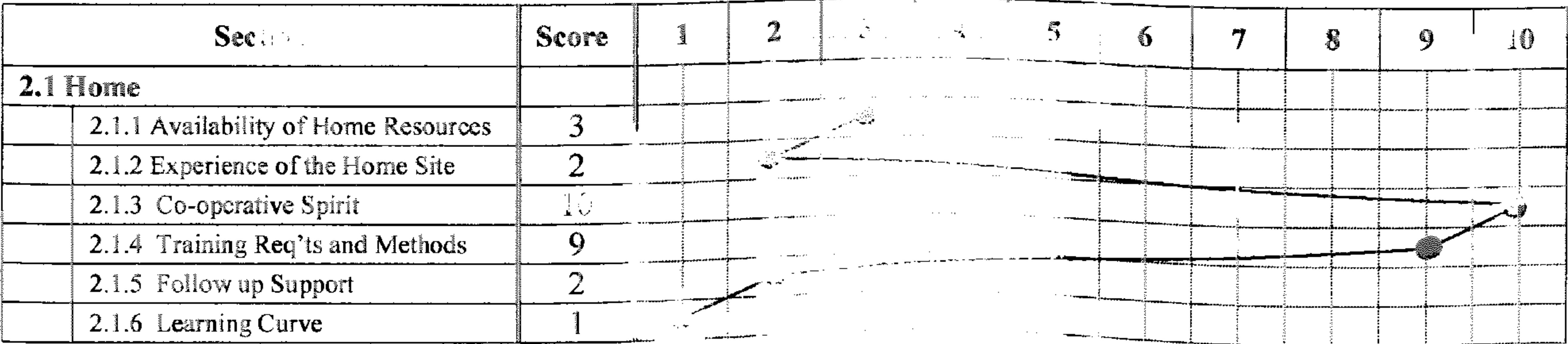


Figure 5-10 Example of Degree of Difficulty Chart

5.6 Summary

This Chapter has described the development of a new framework for international technology transfer. Starting with the content of existing models and building on this the observations made during the case studies and further elements in relevant literature. To make use of the framework as a practical tool, it has been built into a workbook which is intended to be used by those involved to evaluate potential difficulties, prior to commencing the transfer process.

CHAPTER SIX VALIDATION/TESTING PHASE OF THE RESEARCH

6.1 Introduction

The previous Chapter has described how the framework has been developed and how it can be used as a practical tool in the form of a workbook. The objective of this chapter is to review the validation process. This is the testing phase of the research cycle, Meredith et al (1989), it will review the validation process and report the findings and recommendations. Evolving from this process will be proposals for future work.

6.2 Validation of the framework within a workbook

The principal drive for this research was to develop a framework for pre-transfer assessment – useable by practitioners of technology transfer. To meet Thomas and Tymon's (1982) suggestion for operational validity it must meet needs of the practitioner, that is, it will have to be a useable practical tool. Consequently, the method of validation of the framework has been its use within the workbook, this approach places the framework in a working environment.

However, before it can be said to be robust and useful it must be able to withstand the rigour of critique from a panel of experienced industrialists in the field of international technology transfer along with a panel of academics experienced in one or more of the fields of the framework scope.

6.3 Method of validation

Testing and validation of the framework took an iterative cycle in line with Meredith et al's (1989) research cycle, Figure 2-2. That is, the initial framework was developed following the evaluation of the literature review and case studies, tested by the author in a live environment, the findings were further reviewed and the framework modified and extended (3 cycles). It was then reviewed by an internal panel (within University of Plymouth) and the feedback evaluated, the framework was then modified further. Final validation by an external panel of industrialists (users) and academics (experienced in the field of international technology transfer) was carried out. The feedback for this stage is reported in section 6.4. Figure 6-1 shows the stages of validation against the time-line of the research.

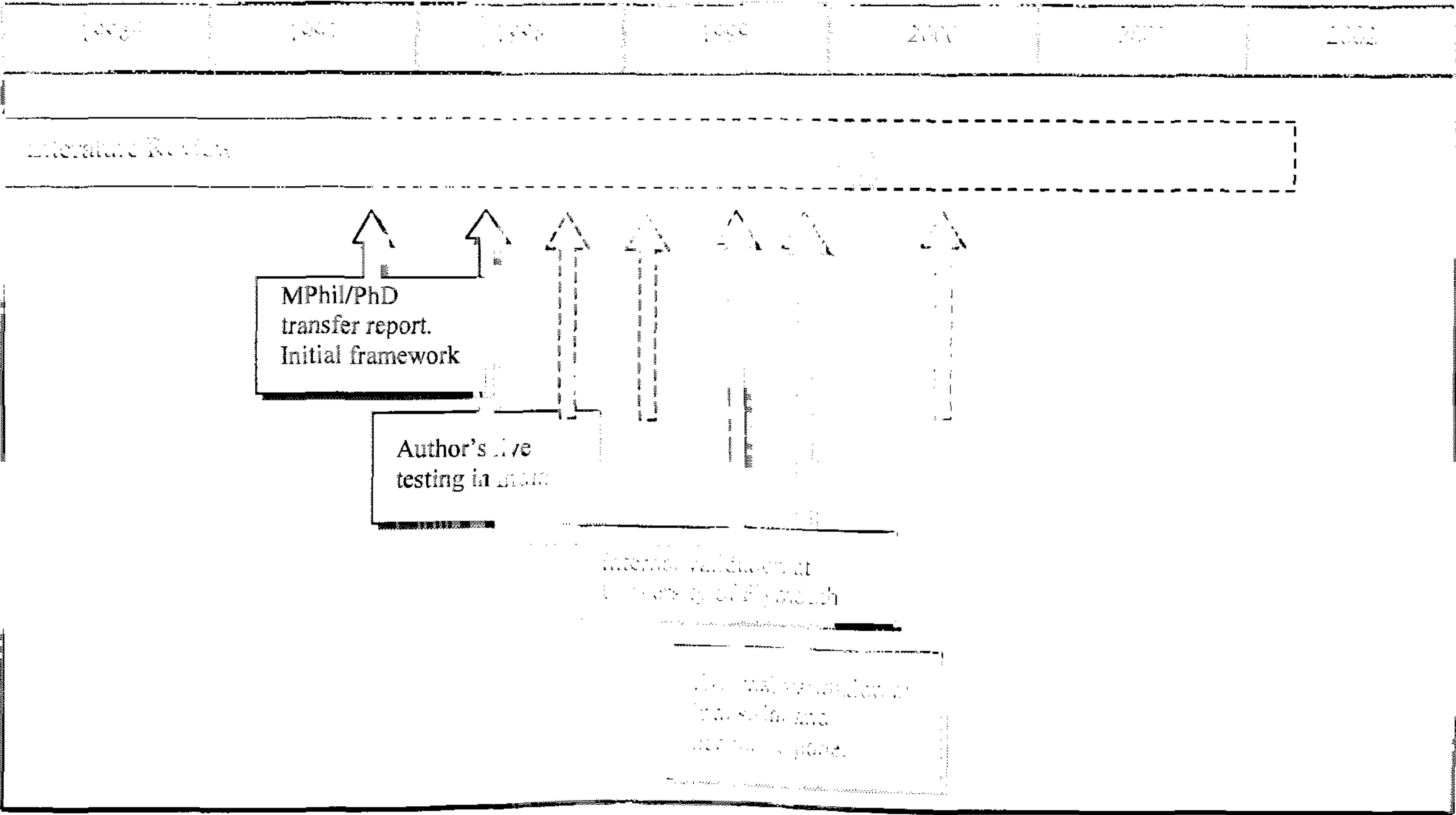


Figure 6-1 Timeline of development and validation of the framework

The following sub-sections will describe the procedure followed.

6.3.1 Live validation by the author

The first version of the workbook was developed and tested in action by the author during the transfer of technologies to the Rittal plant in India. This phase was particularly useful as it guided the author towards a practical, useable approach, improving the robustness of the framework without drawing on members of the validation panel unnecessarily. Therefore, the time of the panel could be focussed on a framework and workbook which had already undergone a number of cycles of the research cycle described in section 2.3.

The live testing by the author was on three occasions between March 1998 and January 1999. Problems which were identified included:

1. Not all of the framework had been developed at the time of the earlier trials and was therefore lacking in scope.
2. No degree of difficulty against the elements being considered. The framework did help the author to identify areas of difficulty but there was no priority or comparative importance identified.
3. The degree of difficulty was originally weighted. This proved extremely difficult to use even though the author was in a position to make all necessary decisions. It was subsequently decided to forego the method of weighting elements and simply allow the user the facility to judge for him/herself what the relative weightings should be applied as the chart is filled in.

6.3.2 Internal validation

Following the physical use in a live environment by the author, but prior to validation by the external panel, the feedback validation sheet was reviewed by an internal panel of senior lecturers from the University of Plymouth. The purpose of the internal validation

was to assess the approach of the questioning – to promote valuable feedback. Those involved were: Mr Jim Pearce, Mr Mike Miles and Dr Chris Rickets. Their comments were evaluated and included in the questionnaire before being circulated to the external panel.

6.3.3 External validation by industrial and academic panel

The validation panel, see Table 6-1, were drawn from individuals experienced in international technology transfer, and academics learned in one of the related fields. Both industrialists and academics were chosen not only for their experience in technology transfer but also their international involvement.

Each member of the panel was sent a copy of the workbook (Appendix 1) and a validation feedback sheet (Appendix 2). The questions on the validation sheet were to be answered by the panel which was designed to establish:

1. Their experience in the field of international technology transfer
2. The relevance of such a framework/workbook as a pre-trial self assessment tool.
3. If the process was representative of the way they currently undertake international technology transfer.
4. The clarity of the approach.
5. Difficulties in completing the workbook.
6. How long did it take to complete the workbook.
7. Does the framework address the problems most MNEs experience.
8. How the framework could be improved.
9. If the workbook covered the elements in sufficient detail.
10. How the workbook could be improved.
11. Other comments.

The validation panel, Table 6-1, consisted of industrialists and academics experienced in the activities of international technology transfer.

Industry	
Mr Ian Maclean	Managing Director – Crickshank and Partners, Aberdeen, UK
Mr Bill Armstrong	Manufacturing and Plant Director – ALSTOM Power, Rugby, UK
Mr Matthias Schüller	Plant Manager – Ethical Corporation, Springfield, USA
Mr John Stewart	Development Manager – Collinson Grant Consultants, Manchester, UK
Mr Mike Jago	Production Director – Toshiba Consumer Products, Plymouth, UK
Mr Dave Green	Product and Process Specialist – ABB, Milton Keynes, UK
Mr Steve Brinan	Managing Director – BSA Machine Tools, Birmingham, UK
Mr Barry Mills	GKN Westland Aerospace, Yeovil, UK
Mr Gary Landrum	Programme Manager – Compaq Computer Corporation, Houston, USA
Mr John Saulec	Global Procurement Manager – Dell Computers, Austin, USA
Academics	
Dr Barber	University of Manchester Institute of Science and Technology, UK
Dr Leonard	University of Manchester Institute of Science and Technology, UK
Prof D Bennett	Aston Business School, UK
Prof Bhattacharrya	Warwick University, UK
Prof De Meyer	INSEAD, Fontainebleau, France
Prof D Jones	University of Cardiff, Wales
Prof Katayama	Waseda University, USA
Dr Marjanovic	Glasgow Caledonian University, UK
Prof New	Cranfield School of Management, UK
Prof Pisano	Harvard Business School, USA
Prof Samli	University of North Florida, USA
Prof Teece	Hass School of Management, University of California, USA
Prof D Tranfield	Cranfield School of Management, UK
Dr Vereecke	University of Ghent, Belgium
Prof X Wang	Renmin University, Beijing, China
Prof Boisot	Imperial College, London, UK
Dr Szulanski	Wharton University, Pennsylvania, USA
Prof Hardt	Massachusetts Institute of Technology, USA

Table 6-1 Validation panel

6.4 Responses

Of the 10 industrial panel and 18 academic panel, only 6 industrialists and 4 academics responded by filling in the validation questionnaire. Prof. Samli responded to explain that he is no longer involved with technology transfer, Prof. New had recently retired and Prof. Tranfield felt that his area of expertise was too far from the heart of this work. In line with the letter of request, Dr Barber of UMIST and Dr Szulanski of Wharton University had both asked one of their PhD students involved with international technology transfer to

complete the questionnaire. Mr Munive replied on behalf of Dr Barber and Mr Jensen replied on behalf of Dr Szulanski.

6.4.1 Summary of the individual responses from the panel

Table 6-4 below shows a summary of the responses from the validation panel. Where possible, the comments are verbatim of the respondent. However, due to space restrictions in some cases the author has compiled a précis of the comments. Where this has been done, care has been taken to ensure that, the intent of the original comment has not been lost.

Mr/Ms/Ms/Mr	Mr/Ms/Ms/Mr	Mr/Ms/Ms/Mr	Mr/Ms/Ms/Mr	Mr/Ms/Ms/Mr	Mr/Ms/Ms/Mr	Mr/Ms/Ms/Mr	Mr/Ms/Ms/Mr	Mr/Ms/Ms/Mr	Mr/Ms/Ms/Mr
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1. Are you participating in any international technology transfer at the moment or have you been involved in the past?

Yes. Previously as the transferor. Currently at strategic level	Yes, \$10M contracts. 2 to China	Yes. From Germany to USA	Development of new products UK/ Sweden	Current – China Previous – Iraq, Iran	Yes. Experience of transferring designs from USA to Netherlands, Taiwan & China from USA and between China & Taiwan	No. I will be involved in one shortly when Rittal transfer the manufacture of the 42U and 24U racks to their factory in the US.	Yes, in charge of setting up INSEAD's campus in Singapore.	Experienced researcher	Yes Previous – USA to Mexico	Yes. In capacity as a researcher.
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2. Do you believe that a pre-transfer questionnaire of this type should be used as part of a technology transfer process?

This approach can help to avoid industry specific technology transfer techniques or actions which neglect broader aspects of the process.	Yes as a starting point. Needs to be complimented with face to face meetings.	Yes	Good for checking	Yes, very important to evaluation process	Yes. There is a great need to understand existing capabilities between the home and host. Being unable to share file formats efficiently can be a great hindrance. Need to understand exactly what new technology is required to scope training.	Yes. I think the questionnaire is a little tedious but the final chart is a really good way of presenting the data.	Yes, it seems to be an interesting tool for an analysis of the hurdles for technology transfer.	Yes	Very useful in the international context for both experienced and inexperienced project managers	This would be useful if modified to allow for other types of knowledge & tech transfer. It could at least give a heads up as to possible problem areas.
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3. Did the pre-transfer assessment approach represent the way in which you undertake international technology transfer?

No. Used a 'common sense' approach based on industry experience which could not cover the scope of this approach.	Yes but the workbook is more structured. Having done it once, would be a better way to do it.	No – most transfers have been carried out in an unstructured way.	No	Yes	Yes & no. Compaq assess a tier of potential partners: 1. A pre-survey where the host describes their business capabilities. 2.On-site survey. 3.Multi-discipline team survey. 4.Allowed to bid.	Yes. It covered all the necessary steps. From dealing with Rittal for over 2 years I can clearly see that it is quite tailored to the Rittal situation. I would not transfer well to some companies.	Not sure Would expand on tacit/ explicit knowledge	Yes: Technical, financial, social, and environmental	No – some important issues were not considered until the project was running	No
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Table 6-2 Summary of validation panel responses

Facilitators			Participants			Explainers		
Mr Anderson	Mr Anderson	Mr Smith	Mr Green	Mr White	Mr Black	Prof. De la Torre	Prof. Brown	Mr. Brown
4. Did you have any difficulties understanding the approach?								
Not at all	Not at all	In some areas – mostly related to terminology	Not at all	Not at all	Not at all. It is very much a pragmatic and logical way to set out detailed information about the host.	Not at all.	Not at all	Not at all. Very understandable and easy to follow
5. Did you have any difficulties completing the questionnaire?								
Not at all In ambiguous cases, score was omitted	Not at all	In some areas – mostly related to terminology	Some areas [Not specified]	Not at all	Not at all.	Not at all	Not at all	In some areas.
6. How long did it take you?								
1 Hour	1 Hour	45 mins	3 Hours	1 Hour	10 Minutes	35 minutes	25 minutes	45 Minutes
7. Do you believe that the pre-transfer assessment framework addresses the issues and problems which most multinational enterprises transferring technology face?								
Yes, it addresses the 'nuts and bolts' issues of transfer.	Yes but see next question	Yes		Yes	Key is - can't have enough information about your partner. Either a formal approach proposed here or informal that requires very knowledgeable ones on both sides.	It does but it is very specific in dealing with issues that Rittal is exposed to German – British and US cultural relations. Fabrication of large metal components.	As said higher, the issue of tacit knowledge is underestimated.	Yes Should include the influence of local government on the host site (environmental regulations)
					See answers to question 2.			
8. How would you like to see the framework improved?								
No improvements required as it is a clear representation of the assessment.	Third party involvement. It may be necessary to take final customers through the process as well.	Would prefer the ability to include more detail. Example: 'Training' – facilities, trainer, people, etc		Its OK	We tend to require outside influences to put requirements and structures in writing before moving forward. It really needs to flow. This looks like a closed loop feedback system.	No real issues here	The workbook presents one way transfer. In many cases technology exchange or technology enrichment is in a complimentary way. This complex situation is not covered here	Also consider: Government policy, infrastructure (power supply), relative law
					The framework itself is not very parsimonious, nor are all of the pieces well defined. I would opt for a smaller more operational model.			

Table 6-3 Summary of validation panel responses (Continued)

Individual responses			As a whole			Prof. Wang			Prof. Young		
Mr. Vaidyan	Mr. Arun Kumar	Mr. Sridhar	Mr. Ganes	Mr. Lakshmi	Mr. Lakshmi	Mr. Lakshmi	Mr. Lakshmi	Mr. Lakshmi	Mr. Lakshmi	Mr. Lakshmi	Mr. Lakshmi
9. Did you feel that the workbook covered all of the elements in sufficient detail?											
Yes, the tips are useful indicators	Expected lifetime of the project. Will it be long term or single project?	See point 8	Yes	Not reviewed in great detail	Yes	Suggest looking at the work of Gabriel Szulanski (Wharton) 'sharing best practices'.	Yes – current workbook is very explicit.				
10. How would you like to see the workbook improved?											
Scope is very specific. Perhaps the introduction could be expanded to explain what other issues might have been considered before using the workbook Example: Financial justification or	Tolerance band on modification to the technology, payback, etc.	Better recognition of country specific preparation for the transfer.	Its OK	Could be generalised to include contract manufacture external to the corporation.	I am not sure if the intention of the workbook is specifically for Rittal or is it intended as a general document. If it is the latter then it needs to be widened a little. The questions are a little tedious	Need to include examples of other technologies, systems, etc.	Would prefer a few lines of space to make own comments on each assessment point..			See comments throughout workbook.	
11. Any other comments?											
		Workbook covers technology transfer in one direction. Doesn't cover the opportunity to transfer back.	Too general. May need customising for some situations	No	This can work. If you put 2.3.2 in writing in USA they would sue your pants off!	I think this is good work. If it is carried out then it will prevent problems that might otherwise arise.	The tool being developed can have a very practical application in industry.				

Table 6-4 Summary of validation panel responses (Continued)

6.4.2 Comments and recommendations

Whilst the number of responses from the panel was not good, there were sufficient comments from some very distinguished people whose judgement is respected internationally.

Overall, all respondents reported positively, most of whom added comments based on their experience. Whilst there are many positive complementary comments which gives reassurance that the framework meets its objectives, it is the constructive criticisms and recommendations which will take the framework forward. The following remarks are noted:

- *“The technology transfer is in one direction”. Mr Schüller and Prof. De Meyer.*

Original thinking was that this aspect seems to be more associated with joint ventures and technology exchange. However, there was one case study at the NMUK site where a technology was transferred from Japan to UK, developed and sent back. Provision could be made for such occurrences.

- *“Third party involvement when completing the assessment”. Mr Armstrong.*

As a procedure to the usefulness of the workbook this would be a useful addition. However, this does not necessarily help the development of the framework itself.

- *“Suggest consideration given to government policy, infrastructure (power supply), relative law”. Prof. Wang.*

The type of technology covered within this research (that with a high tacit content) is unlikely to breach government policies. Nevertheless, if the framework were to be developed for general technology transfer (see further work, section 7.5) the inclusion of government policy could be included. Regarding the infrastructure (power supply),

some changes of machinery may present a problem in some circumstances and this element could also be included.

- *“Too general, may need customising for some situations”. Mr Green.*

The framework and workbook have been designed to be as flexible as possible. If it were changed to become too specific it would lose its usefulness in many applications.

- *“Too specific to Rittal. It needs to be widened a little”. Mr Sadlier*

This is a direct contradiction against Mr Green’s comments. On re-checking the questions and tips, it was found that specific engineering or manufacturing references were to:

- 2.2.1, SMED
- 2.2.2, Castings/Fabrications
- 2.2.5, DIN/ISO Standards
- 2.3.5, 8D/Kaizen.
- 2.3.9, Humidity/water
- 2.3.5, Roll-forming machinery

Whilst roll-forming machinery is specific to sheet metal production, all of the others are generic and applicable to many industries. It is highly probable that Mr Sadlier’s relative inexperience in technology transfer has resulted in his views being guided towards the Rittal activities.

- *“Tacit knowledge is understated”. Prof. De Meyer.*

Tacit knowledge is referred to directly in terms of the level of technological knowledge. However, it is also referred to in several areas indirectly, in terms of: maturity of existing technologies; capability to receive transfers; etc.

- *“Expected life of project. Will it be long term or a single project?” Mr Armstrong.*

In the case of the technology investigated in this research the life of the project is recognised by the availability of the home resources and learning resources at the host site. Having said this, in the context general technology transfer, the suggestion is relevant and could be included.

- *“Would prefer to include more detail. For example: training facilities, trainer, people, etc.” Mr Schüller.*

Although the personnel side of this suggestion is covered, the physical facilities are not. This could be included in the framework.

- *“Tolerance band on the modification to the technology, payback, etc.” Mr Armstrong.*

The tolerance of technology can only be decided with the individual case circumstances. Philosophically speaking, every element of the framework will have a tolerance and each must be treated in it's own right. Similarly, regarding the tolerance on financial questions, individual companies will have their own rules of authority. For instance, some companies will insist that there is no overspend whatsoever without prior approval, whilst others are more than happy to accept a certain amount. It is totally dependant upon the culture of the company.

- *“Need to include examples of other technologies, systems, etc.” Prof. De Meyer.*

The examples are intended to help the person filling in the workbook. Whilst this would give a broader perspective to the workbook, it would do nothing for the framework.

- “If you put 2.3.2⁷ in writing in USA they would sue your pants off”. Mr. Landrum

The author is confident that Mr Landrum has taken the question out of context. However, this does pose the question over the fact that some readers in ethnic sensitive regions of the world may take questions relating to issues of cultural differences as being offensive. There is a significant body of research relating to the cultural aspects of international technology transfer (see section 5.3.1), and any framework omitting this topic would be lacking and incomplete. Consequently the author is satisfied that despite Mr Landrum’s misinterpretation, the aspect of cultural differences must stay in the framework.

Although some of the comments above have relevance to the framework and could be included in a further development of the research, the author considers that there is nothing which fundamentally criticises the framework nor would the suggestions materially improve the framework if they were to be included. Under the circumstances, the framework will be left as it is and considered to be validated and useable.

6.4.3 Degree of difficulty chart

Five of the panel returned the workbook completely filled in based on their experiences. Although this is not the way in which the workbook was intended to be used, pre-assessment as opposed to post recording, it does give a facet of rich information.

One of the comments Prof. De Meyer made was that he always seemed to score at the extremes – suggesting that the scale was too fine. To assess the validity of this remark, all

⁷ This section refers to international cultural differences and is based on the work of Hofstede (1991).

5 of the returned sheets have been tabulated, Table 6-5, and the scores plotted against each other.

Score	1	2	3	4	5	6	7	8	9	10
Prof. De Meyer	12	8	1	2	1	0	4	3	4	1
Mr Green	12	3	7	3	2	2	4	2	0	1
Mr Brittan	1	6	5	5	6	5	3	4	0	1
Prof. Wang	3	9	12	5	2	0	3	1	1	0
Mr Jensen	4	8	5	7	3	4	3	0	0	0
Total:	28	26	25	15	11	7	14	10	5	3
Average:	6.4	6.8	6	4.4	2.8	2.2	3.4	2	1	0.6

Table 6-5 Tabulation of validation panel scores on real life technology transfer cases

The scores reported in Table 6-5 are presented in Figure 6-2 where the frequency of the scores of each of the 4 panel members have been charted.

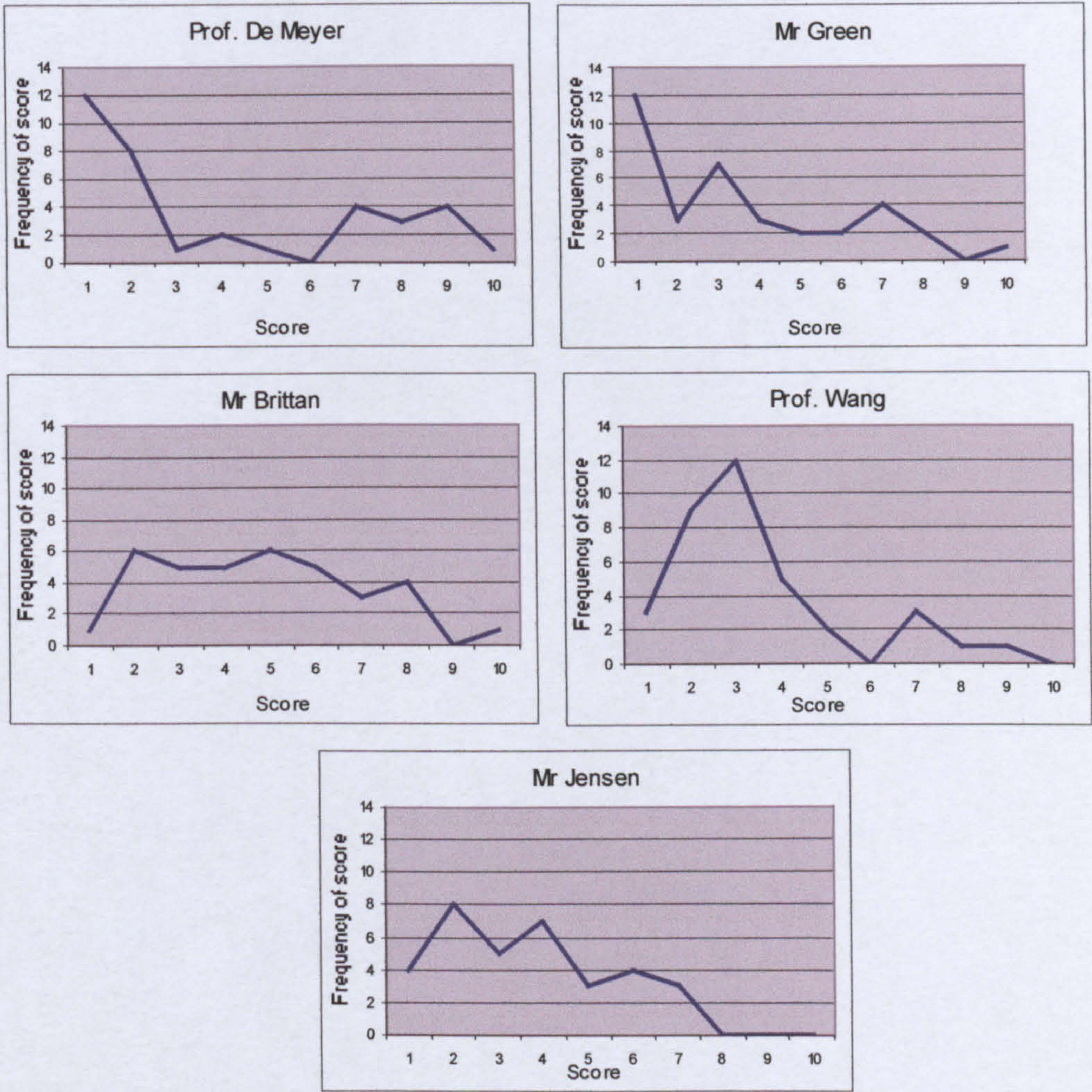


Figure 6-2 Graphical representation of individual assessments

Of the 36 categories scored, it is clear to see that Prof. De Meyer's feeling of scoring at the extremes was only real at the lower end of the scale. It was interesting to see that similar profiles were reported by both Mr Green and Prof. Wang, and to a lesser extent so did Mr Jensen. As stated above, a population of 5 is clearly not enough to form a theory but 4 out of 5 respondents recording the similar profiles certainly opens questions leading to further research. Showing the data collectively and plotting the average score, it can be seen in Figure 6-3 that there is a general tendency to score low. However, care should be exercised, because this trend could be due to the fact that the samples are retrospective scoring where many of the difficulties encountered would have been resolved during the actual transfer process.

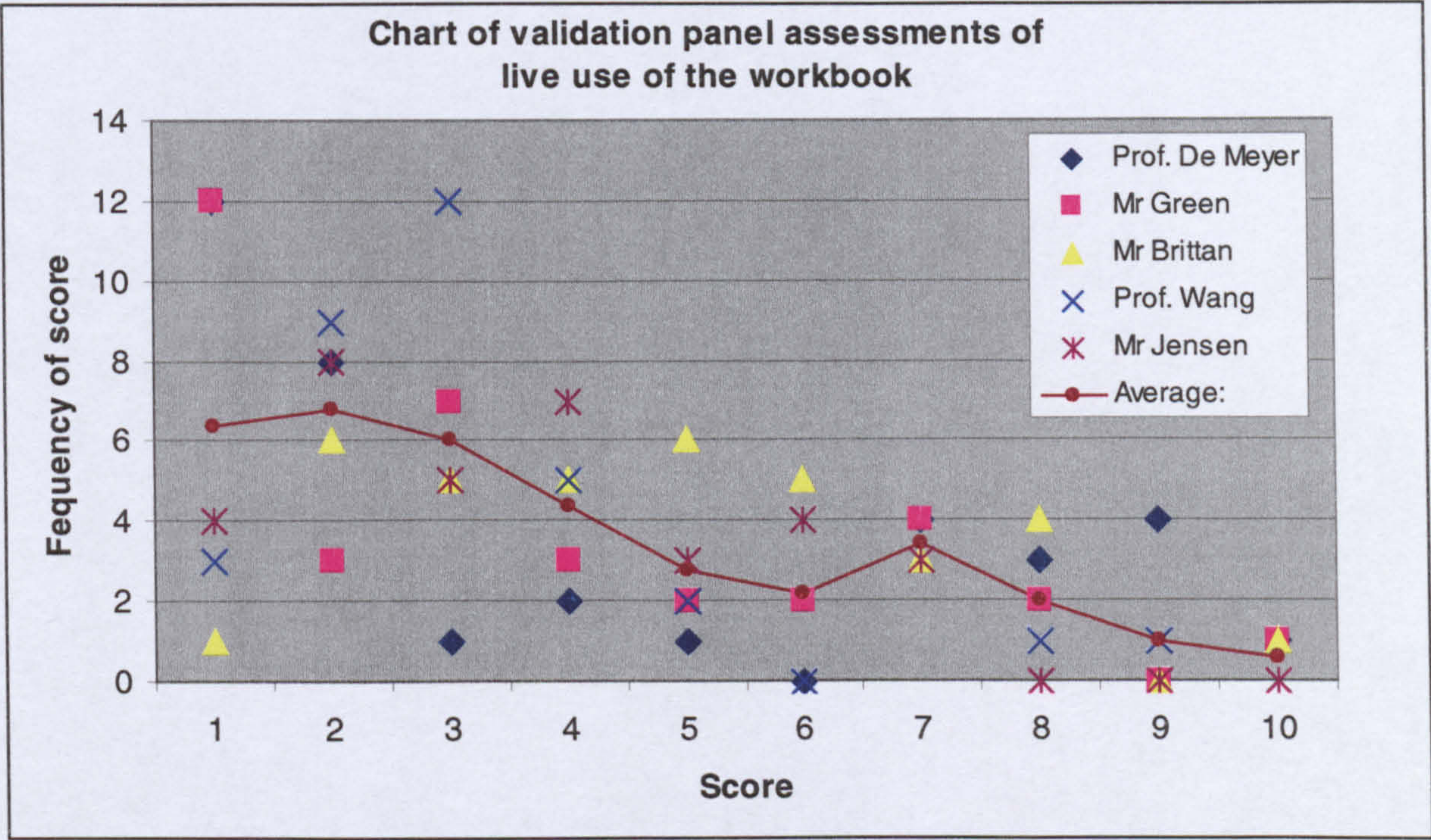


Figure 6-3 Graphical representation of the validation panel scores

6.5 Summary

This Chapter has set out to report the method of validation through the use of a panel, drawing on the practical experiences of both industrialists and academics. Whilst the

number of respondents was small, it was particularly encouraging that many were internationally recognised and respected. This gives significant value to the validation process and the author can be confident that the framework has withstood a rigorous critique. Many constructive comments were received from the panel and these have been addressed above. Where the comments were such that they would be better included in further work then these will be discussed in the next Chapter.

Chapter 7, 'Discussion and conclusions', will review the research as a whole looking at the research methodology, development of the framework, conclusions from the validation and future work which has emerged as a result of this research.

CHAPTER SEVEN DISCUSSION AND CONCLUSIONS

7.1 Introduction

As previously expressed in Chapter 3, the ability to quickly and competently transfer technology between international sites of a global organisation has become a critical competence for firms competing in the global market. The capacity firms have to maximise their already hard earned knowledge will ultimately decide on their future.

Guided by the above maxim, this research has focussed on developing a pre-transfer assessment framework for international technology transfer. The framework will enable firms to prepare themselves prior to undertaking the arduous task of sharing knowledge in an international environment. The research has followed a traditional research methodology and has provided a framework, based on scholarly learning and good quality empirical evidence collected in reputable international organisations. The developed framework has bridged the gaps identified in existing models and through the practical use of a workbook it has proved to be a useful contribution.

This Chapter will discuss the research as a whole, questioning as to whether the research aims and objectives have been met, and discusses aspects highlighted during the research including those elements which lead to further research.

7.2 Research objectives

As explained in section 1.3, the aim of this research study was to investigate international technology transfer and determine if there was a need for a pre-transfer assessment framework. In order to achieve this aim, the objectives of the research were:

1. To select a suitable research methodology, appropriate for international production operations management.
2. To critically review current literature relating to international technology transfer within MNEs and identify gaps in current knowledge.
3. To undertake and evaluate case studies within three multinational organisations.
4. To develop and validate a pre-transfer assessment framework.
5. To provide practitioners of technology transfer with a pre-transfer assessment framework which would enable them to judge where probable difficulties lie, before the transfer phase begins.

7.2.1 Research methodology

The philosophical approach taken in this research regarding the qualitative/quantitative debate was based on the nature of the subject, operations management (Meredith et al (1989), and the decision taken was to follow the qualitative approach. The case studies at Rittal, ALSTOM Power and Nissan Motors UK have all lent themselves to the in depth longitudinal studies appropriate for understanding a process such as international technology transfer, an approach which McCutcheon and Meredith (1993) strongly support as a rigorous research method. However, qualitative case studies are inevitably a subjective means of capturing data. The researcher decides what to look at and what to ignore, what to record and what not, and so on (Kaplan, 1986). Although the phenomena

is studied in its 'natural' environment ... clearly real world, ... completed over time and not a snapshot it allows a greater understanding, however, it can be influential (Hill et al, 1999). Nevertheless, if the researcher has been tempered to the context of the study by the literature and has recognised potential biases, then the effects of subjectivity should be minimised.

In summary, the philosophical approach to the research is well supported by learned researchers. However, the author has been in many cases within the Rittal organisation extremely close to the transfer process and it is possible that despite all efforts to take a neutral view, some of the observations may well have been tainted.

When carrying out research which includes an international context, geographically distant sites are physically demanding for the researcher and it is difficult to revisit a site when a recap on information or progress status is needed. From a research perspective, the author has been in a particularly advantageous position in so much that through his job he has had the facility to regularly revisit sites which in most other research cases would have been cost prohibitive. Consequently, despite the difficulties, a considerable number of site visits have been achieved and a high quality of data recorded.

7.2.2 Literature review

To provide a solid foundation for the research, a thorough literature review was carried out culminating in more than 170 references. The structure of the literature review is presented in Figure 7-1 which shows the focus from global competitiveness through to the gap in existing knowledge – a pre-transfer assessment framework for international technology transfer.

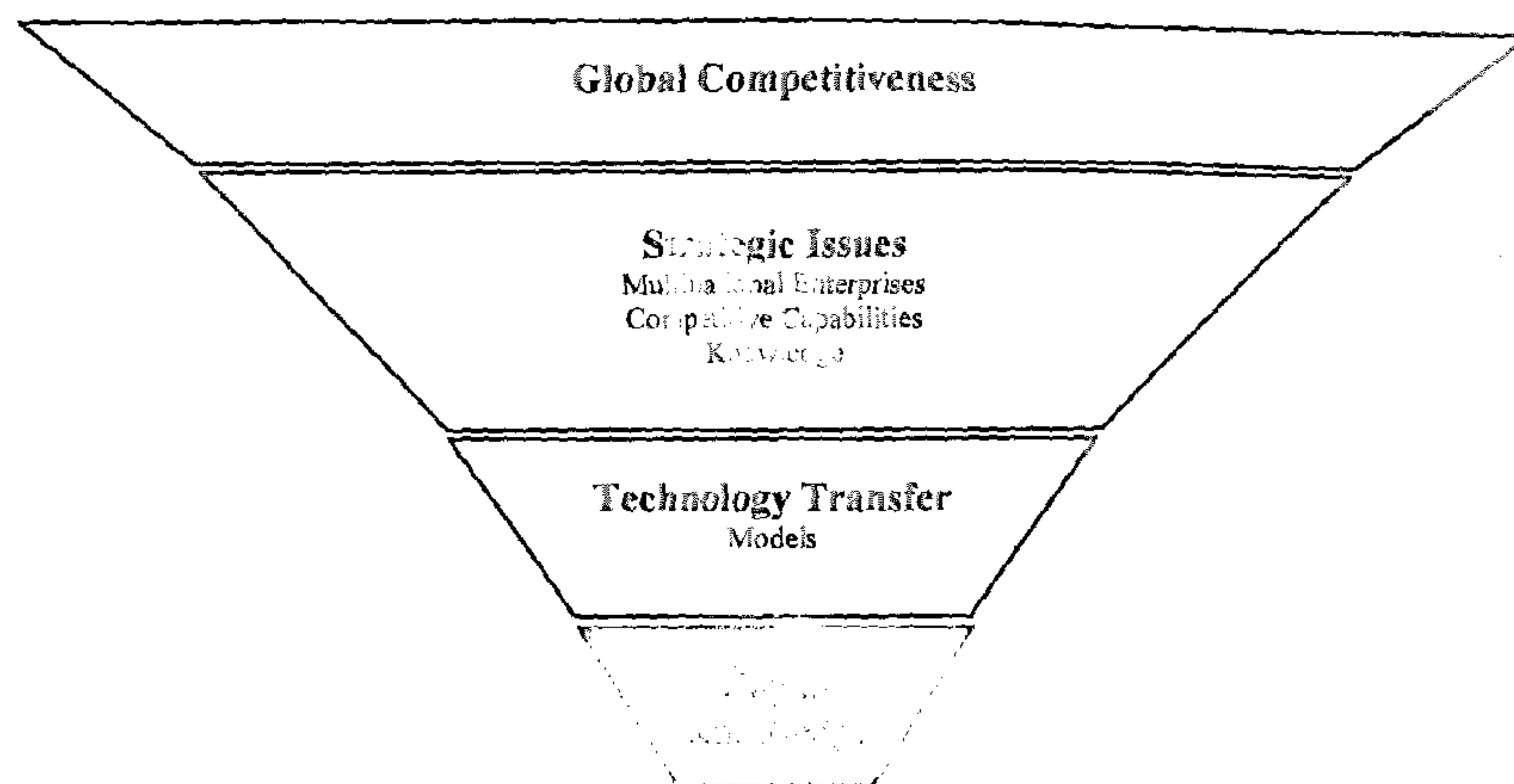


Figure 7-1 Graphical representation of the research focus (previously shown in Chapter 3)

Particular attention was given to the international context of a company along with the importance of the management of its intellectual assets in the form of tacit knowledge. The review presented evidence that there is not only a need for a pre-transfer assessment tool but also that existing models fall some way short of satisfying this requirement. The exposed gap in knowledge has demonstrated a *need* for this research.

Previous authors of technology transfer models and subjects closely related to it have provided an excellent structure to build a suitable framework which satisfies the gap in existing knowledge.

7.2.3 Case studies

Following the basis formed by the literature review the next research objective was to investigate three case study companies Rittal, ALSTOM Power and Nissan Motors UK. The purpose of these was to provide an empirical contribution to the new framework.

Data was collected over an extended period of more than 5 years, satisfying Easterby-Smith et al's (1991) suggestion that in depth longitudinal case studies are appropriate for

Understanding operational management processes such as international technology transfer. The contribution gathered from the case study companies was rich in content due to the true international operations and seniority of the interviewee from each of the of each firms. Additionally, the companies studied are major multi-million pound organisations operating across different continents where cultural and operational differences are vast. These factors made the contributions towards the new framework extremely valuable and have helped to provide a level of robustness to it.

7.2.4 Development and validation of a pre-transfer assessment framework

Due to the popular support of the generic model (Figure 5-2) by many authors, including Aharoni (1991) and Behrman and Wallender (1976), the new pre-transfer framework was formed around it. The relevant components of other models were included along with the content gained from the case studies. Following several progressions of the research cycle, Meredith et al (1989), in a live environment, a detailed complete framework was developed.

The validation, or testing, of the framework was carried out by inviting a mixed panel of academics and industrialists, experienced in international technology transfer to review the framework when used within a pre-transfer assessment workbook. The respondents all gave positive feed back with some constructive recommendations. Confirming that the framework meets its fundamental objectives:

- It is a real contribution to knowledge
 - It is truly useful and useable to practitioners – it has operational validity
- (Thomas and Tymon, 1982).

7.2.5 Workbook

The fifth objective of the research was to provide practitioners of technology transfer with a pre-transfer assessment framework which would enable them to judge where probable difficulties lie, before the transfer phase begins. This has been done by using the framework within a workbook. The workbook was developed by using the framework as the basis for series of questions which prompt the user to judge the potential difficulty of each aspect of the framework.

Through the question section of the workbook, a link is developed between the framework and the user. This places the framework in a useable environment and satisfies the objective, meeting Thomas and Tynan's (1982) requirement for a useable solution.

7.2.6 Summary

The above sections have clearly demonstrated that the objectives of the research project have been met by the development of a useable framework which was validated by both industrial and academic practitioners.

7.3 Contribution to knowledge

This research has critiqued current models and frameworks for international technology transfer and has highlighted the gap in current knowledge – a pre-transfer assessment framework for intra firm use. The technologies investigated are those with a high tacit content, namely:

1. The generic technologies or best practices which firms use in particular ways to improve their competitive capabilities.
2. The specific ways which firms produce their products which again help to achieve their competitive capabilities.

The author's contribution to knowledge is the development of the new framework that not only include elements not contained in previous models and frameworks, it also incorporates two extra dimensions to the inter-site environment: the corporate and global environments. This work is original and provides practitioners of international technology transfer with a conceptual framework that can be applied by means of the workbook.

7.4 Future work

The aim of this research was to develop a framework that would assist practitioners of international technology transfer during the pre-transfer assessment stage of the process. Whilst the new framework has improved understanding of the transfer process and consequentially the ability to pre-judge potential difficulties, the research investigation has revealed facets whereby further research would extend the breadth of knowledge relating to international technology transfer.

There are 4 areas where this research leads to further work:

- The importance of face to face meetings
- The scoring system of the workbook questionnaire.
- The possible use of an electronic workbook.
- Further development of the framework for use as a general framework for manufacturing transfer.

These aspects are discussed in the following sub-sections:

7.4.1 Face to face meetings

An important point highlighted in the literature review was the significance of ‘face to face’ contact. Teece (1981a) emphasises the importance of this aspect when transferring technologies, as a significant amount of the know-how is carried in people’s heads. The importance of face to face contact during the transfer phase is also recognised by:

1. Wang (1994) who not only reports the importance for quality of transfer but also the long term cost benefits.
2. Cross and Baird (2000) who report that individuals are 5 times more likely to gain knowledge from others rather than turning to codified data.

In a similar context, Mr Armstrong, during the validation process, highlighted the desire to include face to face contact between the home and host when completing the workbook. To ensure that there are clear understandings between both parties from the start, differences resolved and that both are aware of the issues ahead and both have “bought into” the project.

The fundamental difference between the two points made above is:

1. The facility for ‘face to face’ contact during the transfer phase.
2. The facility for ‘face to face’ contact during the assessment phase.

Clearly both are important to the success of a transfer project. Although, the first is important regarding the transfer of tacit knowledge, and the second is important regarding commitment of the home and host sites.

7.4.2 Scoring system

Section 6.4.3 reported on the ‘degree of difficulty chart’ as filled in by some of the validation panel. The first aspect of this is the scale proposed by the author 1 – 10. Prof. De Meyer reported that he felt that he was scoring towards the extremes of the scale and himself proposed a “finer scale of 1 – 7”. However, when the scores he made were plotted graphically, it became evident that his extreme scores were only at the lower end of the scale. Similarly, Mr Green and Prof. Wang scored with similar profiles.

With 3 out of the 5 people who filled in the chart showing alike trends, the author feels that further research should be followed from these results providing the opportunity to make this element of such systems more robust.

A small number of the variables which could influence the trend would include:

1. Range of the scale.
2. Commonality of the difficulties encountered. (This has not been carried out due to the unavailability of detailed information about the background of the cases.)
3. Type of technology.
4. Countries involved: cultural issues; language issues; etc.
5. Tendency to score high or low as a natural phenomenon of the assessor.

These aspects may be minimised if it is the same experienced person assessing a project and carrying out the transfer. It would become far more of an issue if one person was assessing a project with little experience and someone else is carrying out the transfer process.

7.4.3 Electronic workbook

When considering the method of completing the workbook in a live situation the author decided that a manual system would be best suited over an electronic version. The reasons for this were:

1. The information to be collected may take the transferor around different parts of the site gathering information from different people. The manual workbook is easily carried. Although, considering the rate of progress in the computer industry on such products as palm-tops, this may well change within a few years.
2. The author believes that when an individual fills in a document themselves, he or she has an amount of commitment or 'buy in' towards the information they have written themselves.
3. Sections can be copied or roughed out easily.
4. As part of a PhD investigation, the paper workbook fits into the thesis and makes reading easier.

However, it is possible that in some circumstances, an electronic version could be developed. Pre-programmed tips for certain technologies could prompt the user and statistical historic data could be drawn on to help with the decision making. Areas such as natural environmental information could be stored about locations world wide which would reduce the time spent collecting data.

In reality, an electronic workbook would probably take a considerable amount of time to develop and even then would be dependent upon the transferor having possession of or access to a suitable portable computer.

7.4.4 Possible use for general technology transfer

Manufacturing processes have been transferred internationally since the industrial revolution but, in more recent times the activity has become more dynamic and frequent (Jeremy, 1992). Amongst the wealth of literature relating to the general subject of 'technology transfer' include: international, intra-firm, joint venture, semi-knocked down, completely knocked down, exchange, etc. and has been the subject of much scholarly research over the past 30 years. Consequently, the focus of much research has generally been onto the transfer of manufacturing processes.

Whilst this research has focused on the intra-firm transfer of technologies which are central to their own competitive capabilities, or their own best practices, the framework could be developed further for use as a general framework which could be used for the transfer of manufacturing. Clearly there are elements which would need to be included such as those highlighted by Prof. Wong in her validation response such as government policies, power supplies, etc.

7.5 Conclusions

Having established that the aims and objectives of the research have been met, this section of the Chapter will evaluate the practical and theoretical implications from the research along with the dichotomies encountered.

7.5.1 Practical implications

The framework in itself can guide the user through the characteristics facing an international technology transfer project. However, this work has sought to take the

framework further by building into the heart of a workbook whereby practitioners can use the findings of this research in a pragmatic way.

As part of the development of the framework, the author has used the workbook in a live environment which proved to be helpful in carrying out the authors job. Additionally, as part of the validation process, 5 members of the panel completed the workbook based on practical experiences. The workbook is in a useable format for further practitioners.

7.5.2 Theoretical implications

The new framework has been built on a foundation of existing knowledge, and developed further by the addition of aspects observed through the case studies. As a research project it has highlighted 4 further research possibilities:

- The importance of face to face meetings
- The scoring system of the workbook questionnaire.
- The possible use of an electronic workbook.
- Further development of the framework for use as a general framework for manufacturing transfer.

This has satisfied the expected contribution from a research project which is to provide openings for new research.

7.5.3 Dichotomies

There are 3 dichotomies identified throughout the research which need expanding on:

1. The first dichotomy is that between tacit and codified knowledge. It has been clearly demonstrated within Chapter 3 that codified knowledge is far easier to transfer than tacit knowledge. This is a critical aspect of this research, in so much that the type of

technology being considered is that which firms have honed into their own best advantage. It must be recognised that this knowledge is what is being transferred. Consequently, it is deeply tacit and largely carried in the heads of the employees. Transferors that can convert tacit knowledge into codified knowledge through videos, photographs, etc. will have far more chance of success.

2. The second dichotomy is that of the home and host site. Cultural differences can affect a smooth transfer through both (i) international cultural difference critiqued in Chapter 5 and (ii) a 'not invented here' mentality as reported from the Nissan Motors UK case study. These are very difficult obstructions to overcome, particularly where there are literally hundreds of scenarios that can exist, depending on the nationality and culture of the home and host sites. Consequently, the management of each situation must be dealt with in its own right.
3. The third dichotomy recognised in this research is that between the head office of an organisation and the individual daughter companies. In all three case studies there was frequent reference to the 'head office', which in most circumstances was in a controlling or directional sense. Nevertheless, it was not difficult to identify a slight resentment to being told what to do and then report (and be measured) against it. This characteristic of MNEs was reported in section 3.3.1 where Birkenshaw & Hood (2001) suggest that as MNEs grow, they like to think for themselves. However, as markets change and commercial viability threatens, many MNEs turn back to the parent company for financial support and transfer of business from other regions. Implicit in this dichotomy and closely linked to the second is the recognition that must be given to the parent company's national cultural behaviour towards the overseas

subsidiaries (Lau and Ngo, 2001). Under these circumstances, a real ‘love/hate’ relationship can develop between the parent/daughter companies.

7.6 Summary

This Chapter has challenged the success of the research project ensuring that the fundamental aims and objectives outlined in Chapter 1 were met. The research objectives were reviewed along with the originality of the work, recommendations for future work and overall conclusions which discussed a number of dichotomies highlighted during the research.

The author is satisfied that through the development of the new framework for international technology transfer the aims and objectives have been met. An original, useable contribution to knowledge has been made and avenues for further research investigation have been identified.



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APPENDICES

1. Workbook
2. Validation feedback papers:
 - 2.1. Ian Maclean. Managing Director, Cruikshank and Partners, Aberdeen, UK
 - 2.2. Bill Armstrong. Manufacturing and Plant Director, ALSTOM Power, Rugby, UK
 - 2.3. Matthias Schüler. Plant Manager, Rittal Corporation, Springfield, USA
 - 2.4. Dave Green. Product and Process Specialist, ABB, Milton Keynes, UK
 - 2.5. Steve Brittan. Managing Director, BSA Machine Tools, Birmingham, UK
 - 2.6. Eduardo Munive. PhD student, University of Manchester Institute of Science and Technology, UK.
 - 2.7. Prof Arnoud De Meyer. Professor/Associate Dean, INSEAD, Fontainbleau, France
 - 2.8. Prof. Wang Xing Ming. Professor, Renmin University, Beijing, China
 - 2.9. Gary Landrum. Programme Manager – Compaq Computer Corporation, Houston, USA.
 - 2.10. John Sadlier. Global Procurement Manager – Dell Computers, Austin, USA
 - 2.11. Mr Jensen. Warton University, Pennsylvania, USA
3. Scored 'Degree of difficulty charts':
 - 3.1. Mr Green
 - 3.2. Mr Brittan
 - 3.3. Prof. De Meyer
 - 3.4. Prof. Wang
 - 3.5. Mr Jensen
4. Case study notes – Alstom Power
5. Case study interview notes – Nissan Motors UK

6. Details of action research site visits

7. Glossary of terms

Appendix 1. Workbook



WORKBOOK

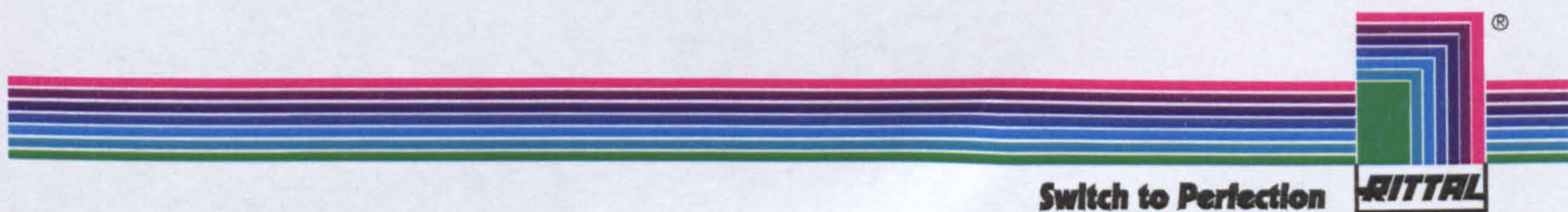
A PRE-TRANSFER ASSESSMENT FRAMEWORK FOR INTERNATIONAL TECHNOLOGY TRANSFER

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1. GUIDELINES

1.1 INTRODUCTION

The purpose of this workbook is to aid the transfer of technology between manufacturing sites of a multinational enterprise. It is intended that it will be used as a pre-transfer assessment tool where companies are trying to improve their intra-firm capabilities.

The type of technologies being considered are those that are key to achieving the companies' competitive capabilities. That is, not the machinery (plant) nor the product, but the 'way' the machinery is used or the product manufactured. The technologies in question will typically be those that help to improve flexibility, quality, delivery/lead-times, cost competitiveness, etc. Fundamentally, the technology transfer is a process for maximising the technological knowledge gained within one part of a multinational enterprise (MNE) and sharing it within other sites of the corporation.

The users of the framework will predominantly be those persons responsible for assessing:

- The necessary resources required to ensure a smooth and successful transfer.
- The difficulties that are likely to be encountered during the transfer process.

The intention is to give an overall representation of the situation visually highlighting the problem areas to the transferor.

1.2 USING THE WORKBOOK

The workbook, represented in Figure 1, is constructed in three major sections:

1. **Guidelines.** Describing the salient components of the pre-transfer assessment including the pre-transfer assessment framework on which the whole assessment is based.
2. **Questionnaire.** A series of questions which the assessor answers, rating the degree of difficulty for each element of the technology transfer process. The assessor considers the obstacles within the intra-MNE, corporate and external environments, which may hinder the success of the transfer.
3. **Degree of Difficulty Chart.** A pull-out sheet to chart the rated degrees of difficulty assessed in section 2. This will give a visual representation of the overall difficulties facing the transferor.

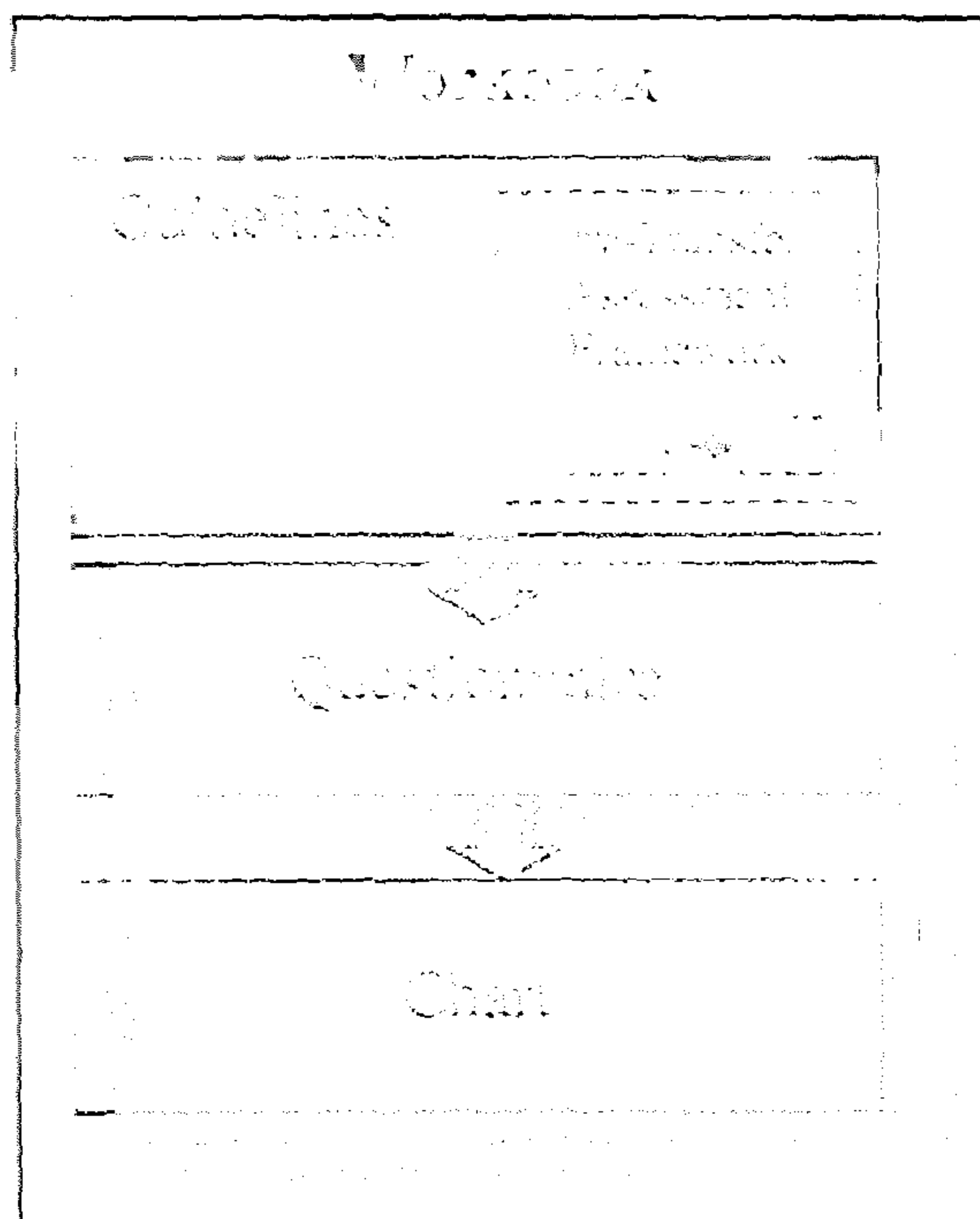


Figure 1 Overview of the Workbook

1.3 THE ASSESSOR

It is anticipated that the person carrying out the assessment will have the ability to assess the home site, the host site and the transfer process, along with having:

- A thorough knowledge of the technology being transferred.
- A thorough knowledge of the operations of the host site, particularly that area in which the technology will be applied.

It is possible that the assessor will be a project manager from the home site, host site or from corporate headquarters.

1.4 THE TRANSFEROR

It is assumed in the text below that the Transferor will be someone who has experience of the technology and knowledge of the host site. In some circumstances 'the transferor' could be more than one person or a team. In many instances the assessor and the transferor will be the same person.

1.5 THE MANUFACTURING STRATEGY

A key element of the framework is the appropriateness of the technology. That is, the Assessor should know and understand the international manufacturing strategy which underpins the management of the company's international factory network.

1.6 THE TECHNOLOGY

The types of technologies which the framework has been developed to transfer are those which are firm specific, that is, technologies embedded in the processes, product and personnel. They can include:

- The application of standard techniques and practices such as Statistical Process Control, Kanban, etc. used in ways which are particular to the company.
- Methods of producing a product which is unique to the company. That is, the way machinery and plant is utilised to produce products in a way that makes them difficult to imitate.
- Personnel embodied activities such as "process tweaking", "machine knack", problem finding and problem solving. Typically those involving individual's know how.

The technological knowledge described above is that which is held in the heads of the employees. It is firm specific, not easily codified and involves significant tacit knowledge.

1.7 PRE-TRANSFER ASSESSMENT FRAMEWORK

The framework is based on an MNE within a global corporation transferring technology to another MNE. That is any MNE can be either the home site transferring or the host site receiving. These can be very complicated, for example, Figure 2 represents the various sequences that can occur when a number of MNEs in a global corporation transfer technology between themselves. The first sequence (blue) represents a situation where the technology is transferred one after another. The second (green) represents a situation where the technology is transferred to the other sites all at once. Thirdly, (yellow) is a combination where the technology is transferred sequentially to the second site and all together to the rest.

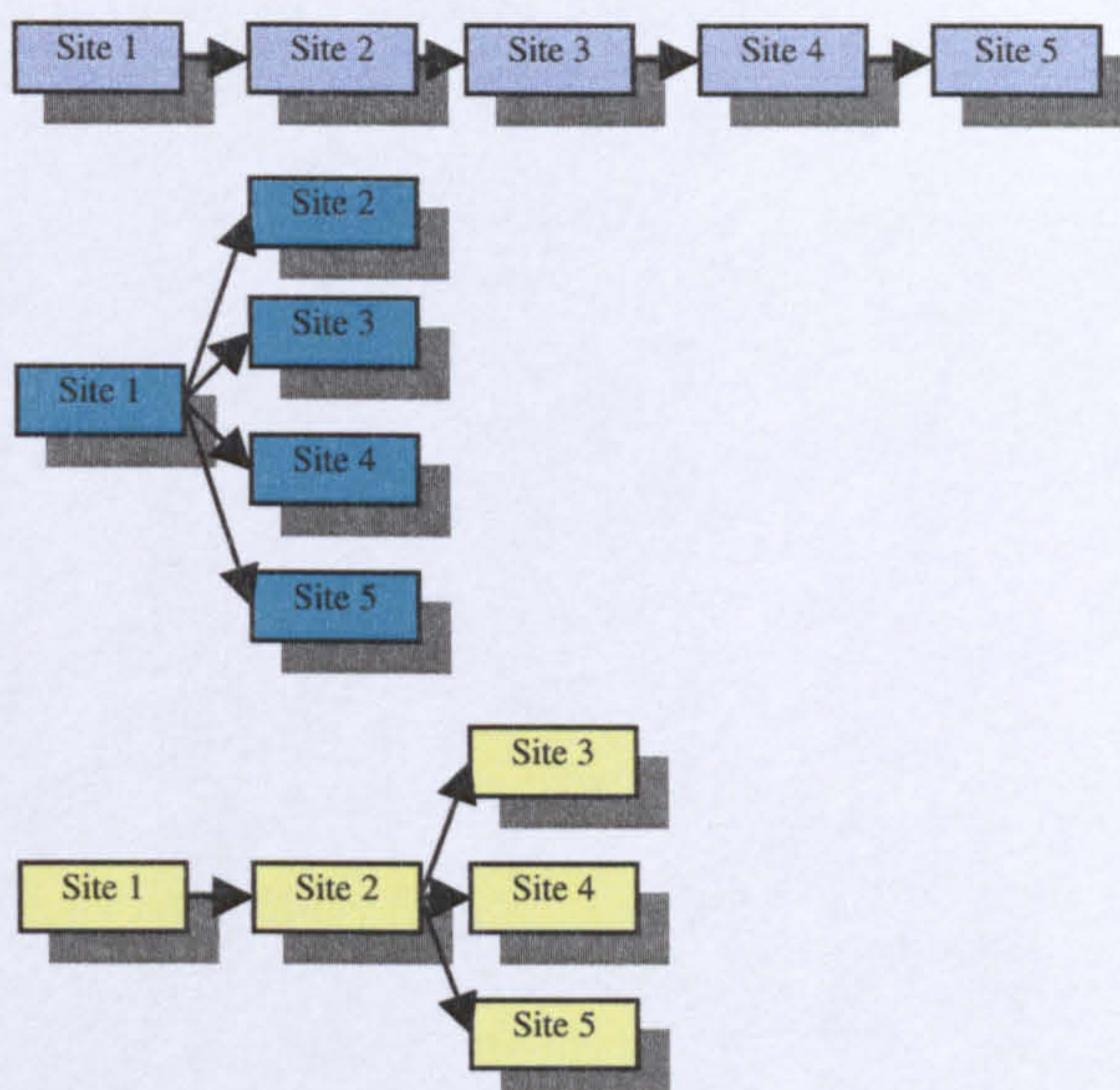


Figure 2 Variations of Technology Transfer Sequences

The example shown above in Figure 2 shows a situation with an example with only 5 sites. Even with only this small number of sites in the network, Figure 3 shows the possible complexities that can occur.

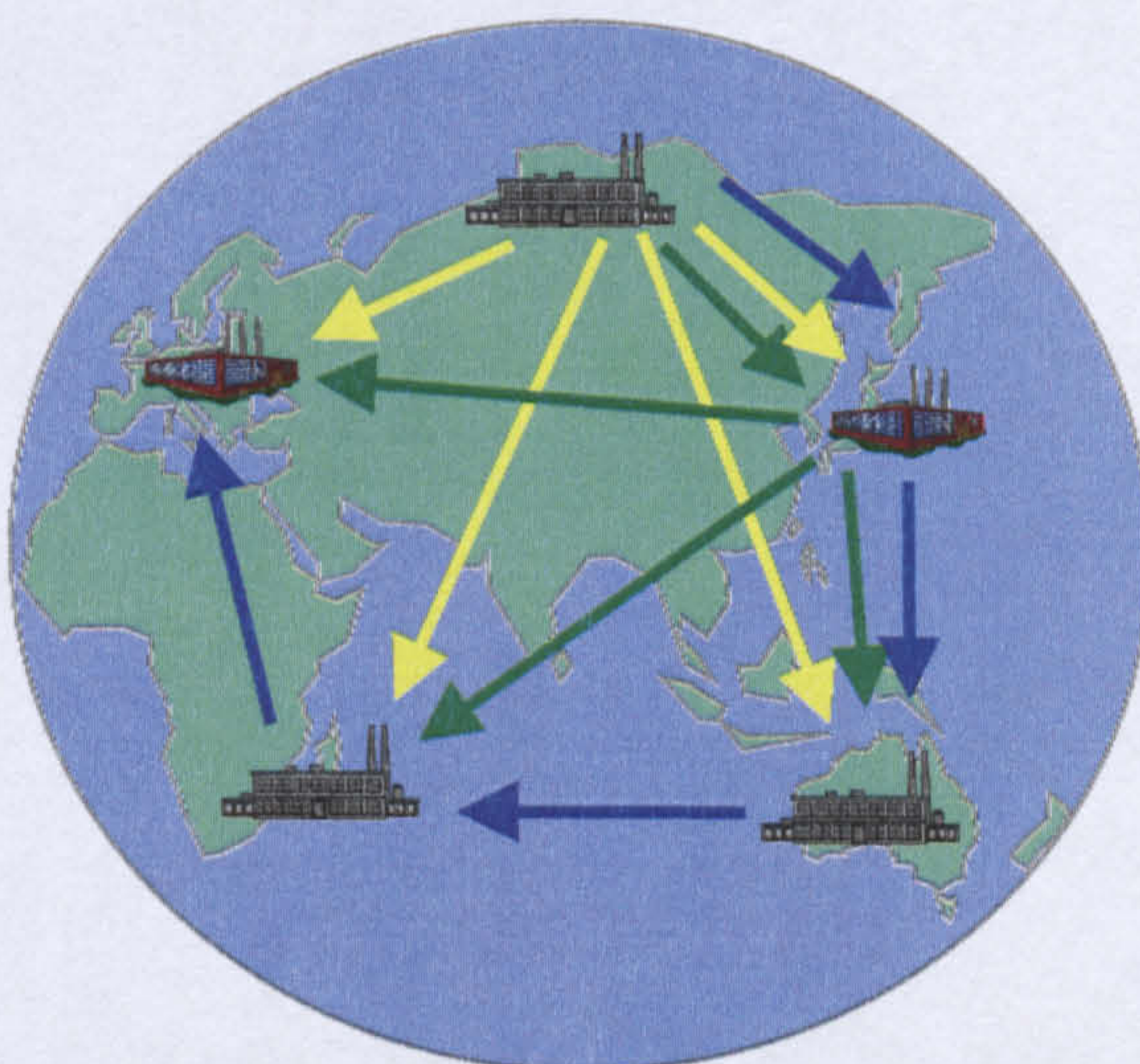


Figure 3 Home/Host relationships

The pre-transfer assessment questionnaire that follows is constructed from the framework shown, Figure 4. The framework encompasses three environments:

1. Intra Multinational Enterprise Environment (blue background). This area includes the influences that affect the technology transfer process between the home and host sites.

2. Corporate Environment (green background). This area includes the relationship between the corporate headquarters and the daughter manufacturing sites.
3. Global Competitive Environment (tan background). This area respects the aspects that affect the need for the MNEs to maximise their competitive capabilities – changing customer requirements.

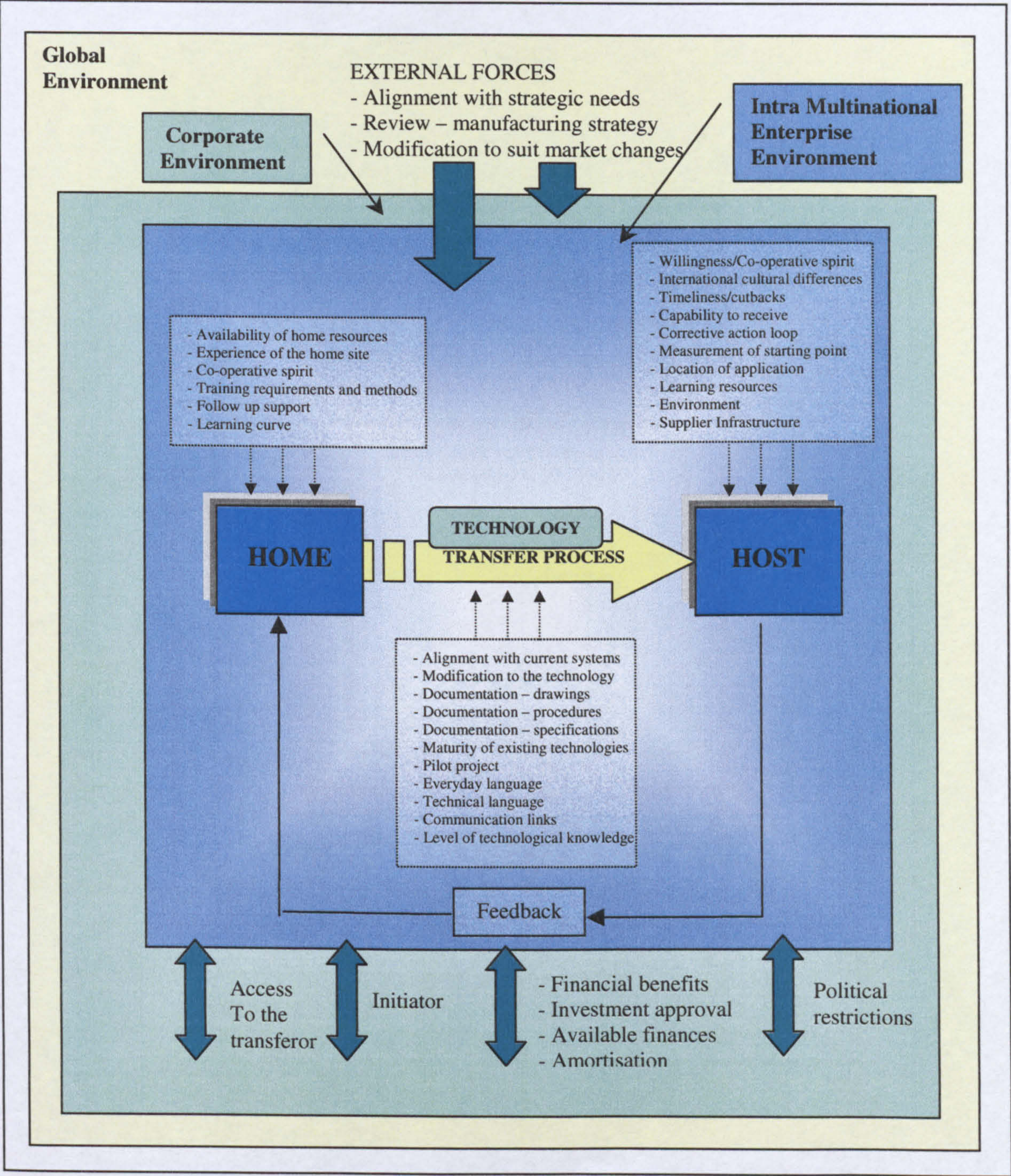


Figure 4 Pre-Transfer Assessment Framework

1.3 PRE-TRANSFER ASSESSMENT QUESTIONNAIRE

The pre-transfer assessment framework is based on three major environments:

1. The MNE Environment which is further broken down between:
 - Home Site – (The Sender)
 - Transfer Process and Technology Characteristics
 - Host Site – (The Recipient)
2. The Corporate Environment - the level within which the MNEs operate.
3. The Global Environment within which the corporation competes in the market.

To enable the assessor to create a visual representation of the difficulties ahead, (see Figure 6 at the end of the questionnaire) an indicator rating is used. The guidelines below suggest a rating that can be used. Please note that the assessment is rating the degree of DIFFICULTY. The rating indicators below are for guidance only.

Proposed rating of difficulty:

- Where the conditions being assessed would yield such answers as No, Poor, Difficult, Bad, etc. The assessor should score high, e.g. 9 or 10.
- Where the conditions being assessed would yield such answers as Yes, Good, Easy, Straightforward, etc. The assessor should score low, e.g. 1 or 2.
- Where the assessor feels that the answer should be somewhere in between then clearly an appropriate score should reflect the assessed situation.

Following the assessment of each section, the 'Score' should be transferred to the 'Degree of Difficulty Chart', Figure 6, similar to the example shown below (see Figure 5). This will provide the assessor with the visual representation of the problem areas.

Example: The table below, Figure 5, is an example of Section 2.1 of the assessment framework and demonstrates how the framework should be filled in. Here, the assessor has judged that the co-operative spirit and training are forecast as being problem areas.

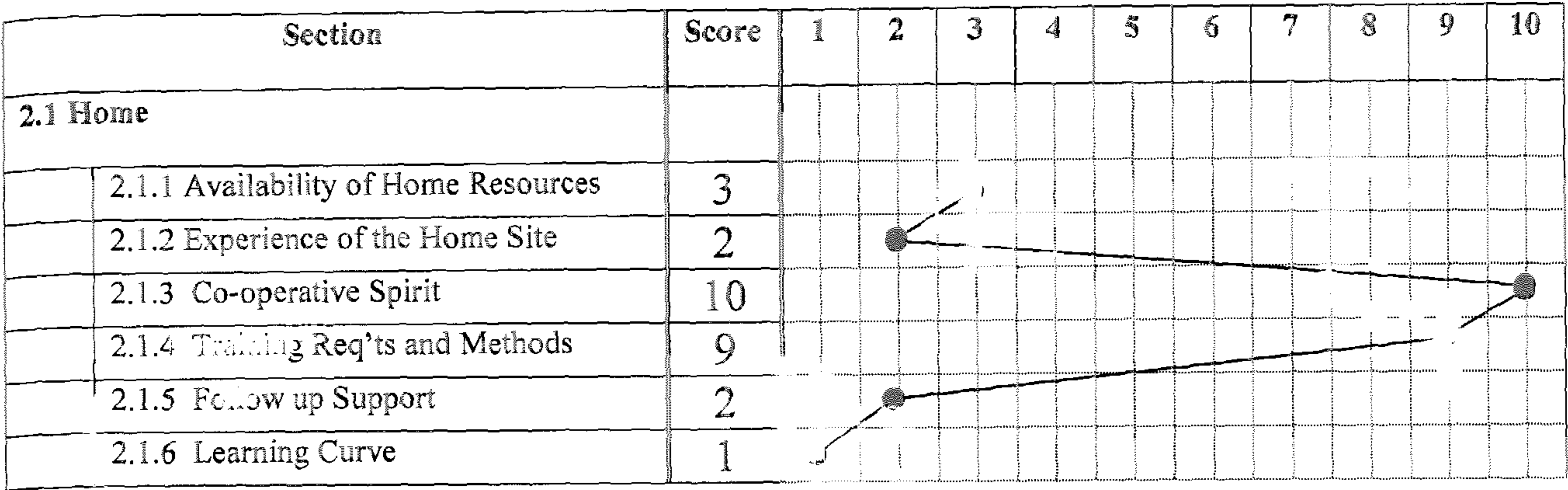


Figure 5 Example of an assessment framework

2. PRE-TRANSFER ASSESSMENT QUESTIONNAIRE

2.1. Home Site

2.1.1 Availability of Home Resources

Rate the availability of the necessary home resources to undertake the technology transfer.

Tip: *Home resources would include not only the capacity of the transferor to be away from the home site but also the capacity around the transferor, such as his/her department, to operate effectively whilst the transferor is undertaking the technology transfer.*

Degree of Difficulty: Score low where home resources are readily available.

Score: _____

2.1.2 Experience of the Home Site

Rate the experience that the home site has with technology transfers.

Tip: *The technology in question may be different to any which may have been received by the host site before, but it is possible that previous experience will prepare the host what to expect.*

Degree of Difficulty: Score high where the home site has little experience.

Score: _____

2.1.3 Co-operative Spirit

Rate the co-operative spirit within the home site transfer team/individual to carry out the technology transfer to the host site?

Tip: *Co-operative spirit within the home site may be low where the result of transferring the technology may have a detrimental effect upon the home site. Possibilities could include the transfer of a technology enabling the host site (a low cost manufacturer?) to undertake the work from the home site, resulting in job losses.*

Degree of Difficulty: Where the co-operative spirit is high, score low.

Score: _____

2.1.4 Training Requirements and Methods

Rate the quality/quantity of formal training for the transfer/introduction of this particular technology within the home site?

Tip: *The host site may have standard training programmes in place for users of the technology. This could include a period of training off line to understand the theory, a period working with an experienced practitioner and then a competence review before being considered competent to operate the technology.*

Degree of Difficulty: Score low where training programmes are already in place.

Score: _____

2.1.5 Follow-up Support

Rate the planned visits for follow-up support

Tip: *This area is not assessing the availability of the transferor but the planned follow-up visits. Consider if follow up visits to the host site will be carried out within a reasonable amount of time after the implementation so that progress can be monitored and necessary action taken.*

Degree of Difficulty: Score low where follow-up visits are frequent and short after the initial transfer.

Score: _____

2.1.6 Learning Curve

This section relates to the technology transfer being carried out in conjunction with other areas within the organisation. Consider if the transfer of the technology to the host site will be in parallel to other sites within the corporation, in series (within a chain) or a combination (see Figure 2).

Rate the financial benefit that the host site will receive from adopting the technology early in the chain or does the technology need bedding into other sites first.

Tip: *The implementation costs will be higher if the host site is early in the sequence. The cost savings from the technology will be higher if implemented early.*
Scenarios to consider:

- *High Cost Savings, High Cost of Implementation*
- *High Cost Savings, Low Cost of Implementation*
- *Low Cost Savings, High Cost of Implementation*
- *Low Cost Savings, Low Cost of Implementation*

Degree of Difficulty: Where the costs outweigh the savings over an appropriate time-scale – score high. Where the savings outweigh the costs – score low.

Score: _____

2.2 Transfer Process and Technology Characteristics

2.2.1 Alignment with Current Systems

Rate how well the technology in question complements other technologies at the host site?

Tip: *If the host site is operating in a market where flexibility is a necessary competence and has already introduced technologies such as ‘single minute exchange of dies’ (SMED), then the introduction of ‘total productive maintenance’ is also likely to complement the necessary competence.*

Degree of Difficulty: Score low for good alignment.

Score: _____

2.2.2 Modification to the Technology	<p>Rate the ‘fit’ of the technology in the form it proven at the home site or does it need to be modified for the host.</p> <p>Tip: <i>Procedures and techniques used to machine large castings will be similar to those used to machine large fabrications. However, it is unlikely that techniques used to machine small components, albeit similar in shape, will help the former.</i></p> <p>Degree of Difficulty: Score low if the ‘fit’ of the technology is good and needs little modification.</p> <p>Score: _____</p>
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Documentation	<p>The next three sections are of particular importance where the transferor will not be attending the host site for extended periods.</p>
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2.2.3 Documentation - Drawings	<p>Rate the availability of drawings that will help the smooth transfer of the technology?</p> <p>Tip: <i>Where drawings do not exist, consider if they be produced easily or if other methods be used such as photographs or videos.</i></p> <p>Degree of Difficulty: Score low where drawings are good quality, suitable and available.</p> <p>Score: _____</p>
--------------------------------	---

2.2.4 Documentation – Procedures	<p>Rate the availability of written procedures describing the operation of the technology?</p> <p>Tip: <i>Where good quality procedures do not exist, consider if they can be easily written for the operation of the technology or can the procedures be described more easily through the use of photographs or videos?</i></p> <p>Degree of Difficulty: Score low where procedures are good quality, suitable and available.</p> <p>Score: _____</p>
----------------------------------	---

2.2.5 Documentation – Specifications

Rate the availability of relevant specifications.

Tip: *This may refer to intra-company agreements, corporate purchasing arrangements or DIN/ISO standards*

Degree of Difficulty: Score low where all specifications are readily available or not necessary.

Score:_____

2.2.6 Maturity of Existing Technologies and Best Practices

Have similar or complementary technologies been embedded and have they reached maturity to the extent that the host site is competent with their application?

Tip: *Some technologies take a long period to master, such as roll-forming sheet steel into complex profiles. Although the machinery could be used to produce several different sections, without a thorough knowledge (and experience) of the technology by the operators and engineers, it is likely to take a long time and a lot of expense to produce new or different profiles.*

Degree of Difficulty: Score low where existing technologies are similar and mature in the host site.

Score:_____

2.2.7 Pilot Project

Rate the credibility that the pilot project will have.

Tip: *Where the introduction of the technology may be contentious it is likely to be important to achieve credibility providing adequate grounding for further implementations. That is, not too easy and resolving a problem that has been well known throughout the company.*

Degree of Difficulty: Score low where the pilot project is suitable and appropriate.

Score:_____

Communication

2.2.8 Everyday Language

Rate the fluency of everyday language between the transferor and the host site.

Tip: *Consider whether the employees of the host site and the transferor speak a common everyday language, or at least, do those speak a common language to such a level that comprehension is not an issue.*

Degree of Difficulty: Score low where fluency is high. Also consider, if fluency is low, can an interpreter be used who can also meet the requirements of 2.2.9

Score: _____

2.2.9 Technical Language

Rate fluency of the technological language between the transferor and the host site.

Tip: *Consider whether the employees of the host site and the transferor both speak a common scientific language (technological terminology) so there is no loss of understanding during the technology transfer.*

Degree of Difficulty: Score low where fluency is high.

Score: _____

2.2.10 Links

Rate the communication links and the ease for the host site to contact the home site or transferor?

Tip: *Points to consider include:*

- *Time differences such that special communication times or links are necessary*
- *The reliability of land-line /mobile telephones, fax, e-mail, video conferencing, etc. to enable discussion and/or present a problem/solution visually.*

Degree of Difficulty: Score low where communication links are easy.

Score: _____

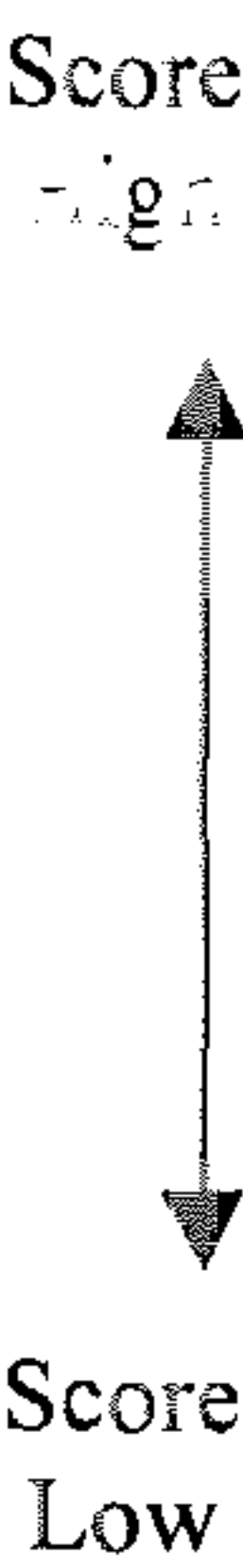
2.2.11 Level of Technological Knowledge

Rate the level of knowledge that the home site has relating to the technology.

Tip: If a process is heavily dependent on experience of operators, with few written procedures – the knowledge being heavily tacit, then the process will be difficult not only to pull out of the home site but also difficult to introduce into the host site.

Degree of Difficulty:

- Ignorance.
- Awareness exists but no knowledge of how to use it. Tacit.
- The variables can be measured/written.
- Variables can be controlled/documented.
- Process capability – manuals. Variables can be controlled with precision.
- Process characterisation (know how).
- Know why.
- Complete knowledge.



Score: _____

2.3 Host

2.3.1 Willingness / Co-operative Spirit

Rate the host sites willingness and positive attitude towards the transfer and the receipt of the new technology into their site?

Tip: Difficulties may arise where a ‘not invented here’ attitude exists, or where the employees of the host site are extremely proud and resist solutions provided to them by a visitor.

Degree of Difficulty: Where the willingness/co-operative spirit is poor, score high.

Score: _____

2.3.2 International Cultural Differences

Rate the effect of the international cultural differences between the home and host site.

Tip: Consider the following:

- **Power – Distance.** The extent to which power is distributed. Including, delegation of authority and consultative approach such as UK, Germany, Holland Denmark and Republic of Ireland or the centralised hierarchical structures preferred in France, Belgium and Portugal.
- **Individualism vs. Collectivism.** Self care and independence versus a tight knit framework of interdependence. Individualistic cultures favouring rewards on merit and a relationship based on mutual benefit such as UK, US, Holland and Denmark, compared with collectivist cultures such as Portugal, Greece, southern Italy, most Asian, Pacific Rim and South American countries where employees expect the company to look after them in exchange for loyalty.
- **Masculine-Feminine.** Macho cultures such as UK, US, Austria, Italy, Japan and Switzerland with assertive, performance driven individuals compared with Scandinavia and the Netherlands where people value more feminine traits such as caring for others and quality of life.
- **Uncertainty avoidance.** How far the people feel threatened by uncertainty and ambiguity. French, Belgians, Spanish, Portuguese and Germans need rules and a formal structure to feel secure, whereas countries like UK, Republic of Ireland, Denmark and Sweden are comfortable with flexibility and accepting dissent.

Degree of Difficulty: Where the cultural differences between the home and host sites are generally small, score low.

Score: _____

2.3.3 Timeliness, Cutbacks

Rate the timeliness of the transfer?

Tip: *Following labour cutbacks or an unsuccessful project, the host site will be unlikely to co-operate with the introduction of new technologies. Note: There may be many other similar reasons.*

Degree of Difficulty: Score high where there have been recent cutbacks.

Score: _____

2.3.4 Capability to Receive

Rate how experienced the host site is with receiving transfers.

Tip: *If the host site is inexperienced, then allowances should be made for a longer implementation period and more frequent visits from representatives from the home site.*

Degree of Difficulty: Score low where the host site has previous experience.

Score: _____

2.3.5 Corrective Action Loop

Rate the host site's systems to correct anomalies and/or undertake continuous improvement.

Tip: *Examples could include the 8D corrective action procedure outlined in ISO 9000, or Kaizen groups being in place.*

Degree of Difficulty: Score low where systems are in place and effective for continuous improvement.

Score: _____

2.3.6 Measurement/
Benchmark of Starting Point

Rate the accuracy of the current operational performances of those aspects to be improved by the technology being measured.

Tip: *If lead-time from receipt of order to delivery of the product is a required competitive competence, then is the current capability accurately known?*

Degree of Difficulty: Score low where the ability to establish an accurate starting point is good.

Score: _____

2.3.7 Location of Application

Rate the introduction of the technology with respect to the location within the company. Consider whether the technology will be transferred into one specific area within the host site or if it will be transferred as a general system intended for company wide use.

Tip: *Attention should be paid towards training large numbers of people and contingencies if the technology is not adopted well or does not work.*

Degree of Difficulty: Score low where the introduction is in one (or a few) area(s).

Score: _____

2.3.8 Learning Resources

Rate the availability of the necessary/sufficient personnel for sufficient time (possibly extended periods) to learn the technology being transferred.

Tip: *In circumstances where the technology will be transferred to other areas within the site, those involved with the initial implementation may possibly become trainers or facilitators.*

Degree of Difficulty: Score high where resources are scarce.

Score: _____

2.3.9 Environment

Rate the effect that the host environment will have on the technology.

Tip: *Some technologies may be affected by heat, humidity, quality of water, etc.*

Degree of Difficulty: Score low where the environment will have little affect on the technology.

Score: _____

2.3.10 Supplier Infrastructure

Rate the supplier infrastructure local to the host site.

Tip: *The introduction of some technologies may require suppliers to adopt a different service to that which they are used to, such as a daily supply of components direct to an assembly line using a kanban system. Consideration should also be given to their geographical location relative to the host site.*

Degree of Difficulty: Score low where suppliers can support the new technology with little or no development at their site.

Score: _____

2.4 Corporate Environment

2.4.1 Political Restrictions

Rate the influence that corporate politics are likely to have on the outcome of the technology transfer.

Tip: *This may be a “take it – like it or not” scenario.*

Degree of Difficulty: Score high where politics may impede the smooth transfer.

Score: _____

2.4.2 Initiator – Pushed from the Sender or Pulled from the Receiver

Rate the influence that the initiator has on the implementation of the technology.

Tip: Consider the influence of a senior manager from head office if he/she is the initiator.

Degree of Difficulty: Score low where the initiator of the technology transfer is located in the host site.

Score: _____

Financial Implications

2.4.3 Benefits

Rate the financial benefits to the home site from the technology transfer?

Tip: The financial benefits for some technologies may not be easily calculated. Such as introducing SMED to increase flexibility as a key competence to meet a changing market requirement.

Degree of Difficulty: Score low where the benefits are significant to the business.

Score: _____

2.4.4 Investment Approval

Rate the amount of delay to the transfer that investment approval will cause.

Tip: Some companies have long drawn out investment approvals which may have a significant affect on payback calculation.

Degree of Difficulty: Score high if the process for securing investments will be long and drawn out; low for little or no investment or for that which will be approved very quickly.

Score: _____

2.4.5 Available Finances

Rate the firm's ability to finance any necessary investments.

Tip: *The company may not be able to finance the technology, irrespective of whether it will yield good financial benefits.*

Degree of Difficulty: Score low if finances are readily available.

Score: _____

2.4.6 Amortisation

Rate the amortisation period for the investment.

Tip: *Will the technology transfer yield financial benefits immediately or will the payback be a long-term issue?*

Degree of Difficulty: Score high where the payback period is long-term relative to normal company investment procedures.

Score: _____

2.4.7 Access to the Transferor

Rate the access that the host site has to the transferor, and the ability for the transferor to visit the host site as required.

Tip: *Consideration should be given to the other commitments which the transferor may have. This element is particularly relevant in large organisations where an individual or small team are employed only to transfer technology globally. Consequently their schedules are generally full and difficult to change.*

Degree of Difficulty: Score low where access and availability are good.

Score: _____

3. DEGREE OF DIFFICULTY CHART

Section	Score	1	2	3	4	5	6	7	8	9	10
INTRA-ZONE ENVIRONMENT											
2.1 Home											
2.1.1 Availability of Home resources											
2.1.2 Experience of the Home Site											
2.1.3 Co-operative Spirit											
2.1.4 Training Requirements and Methods											
2.1.5 Feedback Support											
2.1.6 Learning Curve											
2.2 Transfer Process and Technology Characteristics											
2.2.1 Alignment with Current Systems											
2.2.2 Modification to the Technology											
2.2.3 Documentation – Drawings											
2.2.4 Documentation – Procedures											
2.2.5 Documentation – Specifications											
2.2.6 Maturity of Existing Technologies											
2.2.7 Pilot Project											
2.2.8 Everyday Language											
2.2.9 Technical Language											
2.2.10 Communication Links											
2.2.11 Level of Technological Knowledge											
2.3 Host											
2.3.1 Willingness / Co-operative Spirit											
2.3.2 International Cultural Differences											
2.3.3 Timeliness, Cutbacks											
2.3.4 Capability to Receive											
2.3.5 Corrective Action Loop											
2.3.6 Measurement of Starting Point											
2.3.7 Location of Application											
2.3.8 Learning Resources											
2.3.9 Environment											
2.3.10 Supplier Infrastructure											
2.4 CORPORATE ENVIRONMENT											
2.4.1 Political Restrictions											
2.4.2 Initiator											
2.4.3 Financial Benefits											
2.4.4 Investment Approval											
2.4.5 Available Finances											
2.4.6 Amortisation											
2.4.7 Access to the Transferor											
2.5 EXTERNAL ENVIRONMENT											
2.5.1 Alignment with Strategic Needs											
2.5.2 Review – Manufacturing Strategy											
2.5.3 Modification to Suit Market Changes											

Figure 6 Pre-Transfer Assessment Framework – Chart

Appendix 2 Validation feedback papers

- 2.1. Ian Maclean. Managing Director, Craiksnank and Partners, Aberdeen, UK
- 2.2. Bill Armstrong. Manufacturing and Plant Director, ALSTOM Power, Rugby, UK
- 2.3. Matthias Schüller. Plant Manager, Rittal Corporation, Springfield, USA
- 2.4. Dave Green. Product and Process Specialist, ABB, Milton Keynes, UK
- 2.5. Steve Brittan. Managing Director, BSA Machine Tools, Birmingham, UK
- 2.6. Eduardo Munive. PhD student, University of Manchester Institute of Science and Technology, UK
- 2.7. Prof Arnoud De Meyer. Professor/Associate Dean, INSEAD, Fontainbleau, France
- 2.8. Prof. Wang Xing Ming. Professor, Renmin University, Beijing, China
- 2.9. Gary Landrum. Programme Manager – Compaq Computer Corporation, Houston, USA.
- 2.10. John Sadlier. Global Procurement Manager – Dell Computers, Austin, USA
- 2.11. Mr Jensen. Warton University, Pennsylvania, USA

Validation Sheet

Thank you for agreeing to participate in the validation of the pre-transfer questionnaire. Please complete the questionnaire booklet itself and then answer the validation sheet below.

Please return to:

Stephen Hobbs/
C/o Dr Jan Bennett
Department for Business Development
University of Plymouth
6th Floor, Moneycentre
Plymouth. PL 4 8AA

Feedback sheet completed by:

Name: IAN MACLEAN

Position: MANAGING DIRECTOR

Company/University: CRICKSHANK AND PARTNERS

1. Are you participating in any international technology transfer at the moment or have you been involved in the past?

☒ Yes

☐ No

If yes, please explain involvement and whether your experience is from an industrial perspective or as an experienced researcher:

MY INVOLVEMENT IN THE PAST HAS BEEN
AS THE TRANSFEROR, MY PRESENT INVOLVEMENT IS
AT A STRATEGIC LEVEL OF ALIGNING TECHNOLOGY
TRANSFER WITH COMPANY VISION/OBJECTIVES

2. Do you believe that a pre-transfer questionnaire of this type should be used as part of a technology transfer process?

☒ Yes

☐ No

Comments:

THIS APPROACH CAN HELP AVOID INDUSTRY
SPECIFIC TECHNOLOGY TRANSFER TECHNIQUES OR ACTIONS
WHICH NEGLECT BROADER ASPECTS OF THE PROCESS.

A PRE-TRANSFER ASSESSMENT FRAMEWORK FOR
INTERNATIONAL TECHNOLOGY TRANSFER

3. Did the pre-transfer assessment approach represent the way in which you undertake international technology transfer?

Yes

No

Comments:

WE USED A COMMON SENSE APPROACH BASED
ON INDUSTRY EXPERIENCE WHICH COULD NOT
COVER THE SCOPE OF THIS APPROACH.

4. Did you have any difficulties understanding the approach?

Not at all

In some areas

In most areas

Comments:

5. Did you have any difficulties completing the questionnaire?

Not at all

In some areas

In most areas

Comments:

I TOOK THE VIEW THAT IN CASES OF AMBIGUITY
OR LACK OF RELEVANCE THEN THE SCALE WAS BEST
OMITTED.

6. How long did it take you?

1 HOUR.

7. Do you believe that the pre-transfer assessment framework addresses the issues and problems which most multinational enterprises transferring technology face?

Please specify any areas of the framework that you believe to be incorrect:

YES, IT ADDRESSES THE "NUTS AND BOLTS" ISSUES
OF TRANSFER.

8. How would you like to see the framework (Figure 2) improved?

Please specify any areas of the framework that you would like to see developed further:

NO IMPROVEMENTS REQUIRED AS IT
IS A CLEAR REPRESENTATION OF THE ASSESSMENT.

A PRE-TRANSFER ASSESSMENT FRAMEWORK FOR
INTERNATIONAL TECHNOLOGY TRANSFER

9. Did you feel that the workbook covered all of the elements in sufficient detail?

YES, THE TIPS ARE USEFUL INDICATORS.

10. How would you like to see the workbook improved?

Please specify any areas of the questionnaire that you would like to see developed further:

THE SCOPE OF THE WORKBOOK IS VERY SPECIFIC BUT PERHAPS THE INTRODUCTION COULD BE EXPANDED TO EXPLAIN WHAT OTHER ISSUES MIGHT HAVE BEEN CONSIDERED BEFORE USING THE WORKBOOK

11. Any other comments?

E.G. FINANCIAL JUSTIFICATION OR STRATEGIC REASONING / OPTIONS FOR TRANSFER.

Thank you for your time and help. Your comments will be treated in confidence and considered in the development of the final framework.

A PRE-TRANSFER ASSESSMENT FRAMEWORK FOR
INTERNATIONAL TECHNOLOGY TRANSFER

Validation Sheet

Thank you for agreeing to participate in the validation of the pre-transfer questionnaire. Please complete the questionnaire booklet itself and then answer the validation sheet below.

Please return to:

Stephen Hobbs/
C/o Dr Ian Bennett
Department for Business Development
University of Plymouth
6th Floor, Moneycentre
Plymouth. PL 4 8AA

Feedback sheet completed by:

Name: *Bill Armstrong.*

Position: *Manufacturing and Plant Director.*

Company/University: *A33 Alston Power.*

1. Are you participating in any international technology transfer at the moment or have you been involved in the past?

☒ Yes

☐ No

If yes, please explain involvement and whether your experience is from an industrial perspective or as an experienced researcher: 'INDUSTRIAL'

Negotiation and management of a \$10M contract for localisation and technology transfer of a current project for 2 Nuclear powered Steam Turbine plants for PRC. Leading to future projects with increasing levels of Technology Transfer and localisation.

2. Do you believe that a pre-transfer questionnaire of this type should be used as part of a technology transfer process?

☒ Yes

☐ No

Comments:

As a starting point, it needs to be complemented with face to face meetings to ensure above all that both parties are committed to its success. ie. Is there a market / project with benefits for both.

A PRE-TRANSFER ASSESSMENT FRAMEWORK FOR
INTERNATIONAL TECHNOLOGY TRANSFER

3. Did the pre-transfer assessment approach represent the way in which you undertake international technology transfer?

☒ Yes

☐ No

Comments: But not in as structured way as this agreed. However having done it once this would be a better way to do it in future.

4. Did you have any difficulties understanding the approach?

☒ Not at all

☐ In some areas

☐ In most areas

Comments:

5. Did you have any difficulties completing the questionnaire?

☒ Not at all

☐ In some areas

☐ In most areas

Comments:

6. How long did it take you? 1 hr.

7. Do you believe that the pre-transfer assessment framework addresses the issues and problems which most multinational enterprises transferring technology face?

Please specify any areas of the framework that you believe to be incorrect:

Yes but see next question.

8. How would you like to see the framework (Figure 2) improved?

Please specify any areas of the framework that you would like to see developed further:

Third party involvement.

e.g. Is there a requirement to take final customers with you during the process. If the prime reason for IT is cost reductions then would or low cost countries are likely to play a key part. If this is the case will they be acceptable to the end customer. Do they have international qualifications, what additional commercially recognised support is

A PRE-TRANSFER ASSESSMENT FRAMEWORK FOR
INTERNATIONAL TECHNOLOGY TRANSFER

9. Did you feel that the workbook covered all of the elements in sufficient detail?

What is the expected lifetime of the project? What would you expect the recipient of the technology to push for in the future. Are you prepared to plan a long term TT or just one project specific, if not is that what the recipient wants!

10. How would you like to see the workbook improved?

Please specify any areas of the questionnaire that you would like to see developed further:

Questions on the 'tolerance band' that you are prepared to consider for modifying the approach, to payback, scope etc of the project to meet changing recipient, environment and customer needs.

11. Any other comments?

Thank you for your time and help. Your comments will be treated in confidence and considered in the development of the final framework.

Validation Sheet

Thank you for agreeing to participate in the validation of the pre-transfer questionnaire. Please complete the questionnaire booklet itself and then answer the validation sheet below.

Please return to:

Stephen Hobbs/
C/o Dr Jan Bennett
Department for Business Development
University of Plymouth
6th Floor, Moneycentre
Plymouth. PL 4 8AA

Feedback sheet completed by:

Name: *Matthias Schüler*

Position: *Plant Manager*

Company/University: *RiHal Corp. (USF)*

1. Are you participating in any international technology transfer at the moment or have you been involved in the past?

☒ Yes

☐ No

If yes, please explain involvement and whether your experience is from an industrial perspective or as an experienced researcher:

Involved with transferring technology from Germany to USF

2. Do you believe that a pre-transfer questionnaire of this type should be used as part of a technology transfer process?

☒ Yes

☐ No

Comments:

A PRE-TRANSFER ASSESSMENT FRAMEWORK FOR
INTERNATIONAL TECHNOLOGY TRANSFER

3. Did the pre-transfer assessment approach represent the way in which you undertake international technology transfer?

Yes

No

Comments: Most transfers ~~are~~ have been carried out in an unstructured way.

4. Did you have any difficulties understanding the approach?

Not at all

In some areas

In most areas

Comments: Mostly related to Terminology

5. Did you have any difficulties completing the questionnaire?

Not at all

In some areas

In most areas

Comments: See above

6. How long did it take you?

45 min.

7. Do you believe that the pre-transfer assessment framework addresses the issues and problems which most multinational enterprises transferring technology face?

Please specify any areas of the framework that you believe to be incorrect:

Yes

8. How would you like to see the framework (Figure 2) improved?

Please specify any areas of the framework that you would like to see developed further:

Would prefer the ability to include more detail between each element. Example Training - facilities, Trainer, people, etc

A PRE-TRANSFER ASSESSMENT FRAMEWORK FOR
INTERNATIONAL TECHNOLOGY TRANSFER

9. Did you feel that the workbook covered all of the elements in sufficient detail?

See Point 8

10. How would you like to see the workbook improved?

Please specify any areas of the questionnaire that you would like to see developed further:

Better recognition of country "specific" preparation for the Transfer

11. Any other comments?

Whilst the workbook covers technology Transfer in one direction it doesn't cover the opportunities of the Transfer learning other technologies to transfer back

Thank you for your time and help. Your comments will be treated in confidence and considered in the development of the final framework.

8/9/00

M. Schult

Validation Sheet

Thank you for agreeing to participate in the validation of the pre-transfer questionnaire. Please complete the questionnaire booklet itself and then answer the validation sheet below.

Please return to:

Stephen Hobbs/
C/o Dr Jan Bennett
Department for Business Development
University of Plymouth
6th Floor, Moneycentre
Plymouth. PL 4 8AA

Feedback sheet completed by:

Name: D. GREEN

Position: PRODUCT AND PROCESS SPECIALIST - ARC WELDING

Company/University: ABB FLEXIBLE AUTOMATION

1. Are you participating in any international technology transfer at the moment or have you been involved in the past?

☒ Yes

☐ No

If yes, please explain involvement and whether your experience is from an industrial perspective or as an experienced researcher:

INDUSTRIAL - DEVELOPMENT OF NEW PRODUCT.

2. Do you believe that a pre-transfer questionnaire of this type should be used as part of a technology transfer process?

☒ Yes

☐ No

Comments:

GOOD 'CHECKING' INFORMATION.

A PRE-TRANSFER ASSESSMENT FRAMEWORK FOR
INTERNATIONAL TECHNOLOGY TRANSFER

3. Did the pre-transfer assessment approach represent the way in which you undertake international technology transfer?

Yes

No

Comments:

4. Did you have any difficulties understanding the approach?

Not at all

In some areas

In most areas

Comments:

5. Did you have any difficulties completing the questionnaire?

Not at all

In some areas

In most areas

Comments:

6. How long did it take you?

APPROX. 3 HOURS.

7. Do you believe that the pre-transfer assessment framework addresses the issues and problems which most multinational enterprises transferring technology face? YES.

Please specify any areas of the framework that you believe to be incorrect:

8. How would you like to see the framework (Figure 2) improved?

Please specify any areas of the framework that you would like to see developed further:

A PRE-TRANSFER ASSESSMENT FRAMEWORK FOR
INTERNATIONAL TECHNOLOGY TRANSFER

9. Did you feel that the workbook covered all of the elements in sufficient detail?

10. How would you like to see the workbook improved?

Please specify any areas of the questionnaire that you would like to see developed further:

11. Any other comments?

THE WORKBOOK IS VERY GENERAL. IT MAY REQUIRE SOME CUSTOMISING FOR SOME SITUATIONS.

PLEASE CALL ME IF YOU WISH TO DISCUSS MY EXPERIENCE.

IT MAY BE INTERESTING FOR YOU TO KNOW, THAT THE RESULT

OF MY ONE YEAR ASSIGNMENT WAS RESULTED IN A 50/50

RRING SPLIT BETWEEN MILTON KEYNES AND LAKA.

Thank you for your time and help. Your comments will be treated in confidence and considered in the development of the final framework.

A PRE-TRANSFER ASSESSMENT FRAMEWORK FOR
INTERNATIONAL TECHNOLOGY TRANSFER

Validation Sheet

81 DEC 1999

Thank you for agreeing to participate in the validation of the pre-transfer questionnaire. Please complete the questionnaire booklet itself and then answer the validation sheet below.

Please return to:

Stephen Hobbs/
C/o Dr Jan Bennett
Department for Business Development
University of Plymouth
6th Floor, Moneycentre
Plymouth. PL 4 8AA

Feedback sheet completed by:

Name: **STEVE BRITAN**

Position: **MANAGING DIRECTOR**

Company/University: **BSA TOOLS LTD**

1. Are you participating in any international technology transfer at the moment or have you been involved in the past?

☒ Yes

☐ No

If yes, please explain involvement and whether your experience is from an industrial perspective or as an experienced researcher:

INDUSTRIAL PERSPECTIVE.

JO CO-PRODUCTION AGREEMENT IN CHINA - CURRENT.

USE OF TECHNOLOGY AGREEMENT IN IRAQ - PREVIOUS.

USE OF TECHNOLOGY AGREEMENT IN IRAN - PREVIOUS.

2. Do you believe that a pre-transfer questionnaire of this type should be used as part of a technology transfer process?

☒ Yes

☐ No

Comments: **VERY IMPORTANT TO EVALUATION PROCESS.**

A PRE-TRANSFER ASSESSMENT FRAMEWORK FOR
INTERNATIONAL TECHNOLOGY TRANSFER

3. Did the pre-transfer assessment approach represent the way in which you undertake international technology transfer?

Yes

No

Comments:

4. Did you have any difficulties understanding the approach?

Not at all

In some areas

In most areas

Comments:

5. Did you have any difficulties completing the questionnaire?

Not at all

In some areas

In most areas

Comments:

6. How long did it take you?

1 Hour.

7. Do you believe that the pre-transfer assessment framework addresses the issues and problems which most multinational enterprises transferring technology face?

Please specify any areas of the framework that you believe to be incorrect:

Yes.

8. How would you like to see the framework (Figure 2) improved?

Please specify any areas of the framework that you would like to see developed further:

ITS O.K.

A PRE-TRANSFER ASSESSMENT FRAMEWORK FOR
INTERNATIONAL TECHNOLOGY TRANSFER

9. Did you feel that the workbook covered all of the elements in sufficient detail? *YES*.

10. How would you like to see the workbook improved? *IT'S OK.*
Please specify any areas of the questionnaire that you would like to see developed further:

11. Any other comments? *NO*.

Thank you for your time and help. Your comments will be treated in confidence and considered in the development of the final framework.

A PRE-TRANSFER ASSESSMENT FRAMEWORK FOR
INTERNATIONAL TECHNOLOGY TRANSFER

Validation Sheet

Thank you for agreeing to participate in the validation of the pre-transfer questionnaire. Please complete the questionnaire booklet itself and then answer the validation sheet below.

Please return to:

Stephen Hobbs/
C/o Dr Jan Bennett
Department for Business Development
University of Plymouth
6th Floor, Moneycentre
Plymouth. PL 4 8AA

Feedback sheet completed by:

Name: Eduardo Munive

Position: Ph D student

Company/University: UMIST Total Technology Department

1. Are you participating in any international technology transfer at the moment or have you been involved in the past?

☒ Yes ☐ No

If yes, please explain involvement and whether your experience is from an industrial perspective or as an experienced researcher:

In 1994 I was a member of the Manufacturing Engineering Department at Groupe Schneider - Tlaxcala Mexico Facility. I was involved in the transfer of some systems (Powder Coating) and production lines (Square D QO Load Centers) from Raleigh N.C. USA to the facility in Mexico.

2. Do you believe that a pre-transfer questionnaire of this type should be used as part of a technology transfer process?

☒ Yes ☐ No

Comments:

I found this questionnaire very useful to assist the transfer of technology in the international context by both little experienced or skilled project managers.

A PRE-TRANSFER ASSESSMENT FRAMEWORK FOR
INTERNATIONAL TECHNOLOGY TRANSFER

3. Did the pre-transfer assessment approach represent the way in which you undertake international technology transfer?

Yes

☒ No

Comments: Unfortunately, when I was working with Groupe Schneider, some important issues were not considered until the project was already running.

4. Did you have any difficulties understanding the approach?

☒ Not at all

☐ In some areas

☐ In most areas

Comments:

I think the structure of the approach is very understandable and easy to follow.

5. Did you have any difficulties completing the questionnaire?

☒ Not at all

☐ In some areas

☐ In most areas

Comments:

6. How long did it take you?

About 2 hours

7. Do you believe that the pre-transfer assessment framework addresses the issues and problems which most multinational enterprises transferring technology face?

Please specify any areas of the framework that you believe to be incorrect:

I found the framework very complete. I think it should be necessary to include the influence of the local government on the Host site (environmental regulations, etc.).

8. How would you like to see the framework (Figure 2) improved?

Please specify any areas of the framework that you would like to see developed further:

I think that the current state of the framework is correct.

A PRE-TRANSFER ASSESSMENT FRAMEWORK FOR
INTERNATIONAL TECHNOLOGY TRANSFER

9. Did you feel that the workbook covered all of the elements in sufficient detail?

Yes, I think the workbook is very explicit.

10. How would you like to see the workbook improved?

Please specify any areas of the questionnaire that you would like to see developed further:

I think it would be very helpful for the assessor if you could include a couple of blank lines for writing their own comments on each assessment point of the questionnaire.

11. Any other comments?

I think that the tool you are developing can have a very practical application in industry. I wish I had have such an aid when I was working in Groupe Schneider and I didn't have any experience at all in international technology transfer.

Thank you for your time and help. Your comments will be treated in confidence and considered in the development of the final framework.

A PRE-TRANSFER ASSESSMENT FRAMEWORK FOR
INTERNATIONAL TECHNOLOGY TRANSFER

Validation Sheet

Thank you for agreeing to participate in the validation of the pre-transfer questionnaire. Please complete the questionnaire booklet itself and then answer the validation sheet below.

Please return to:

Stephen Hobbs/
C/o Dr Jan Bennett
Department for Business Development
University of Plymouth
6th Floor, Moneycentre
Plymouth. PL 4 8AA

Feedback sheet completed by:

Name: **Armand D E MEYER**

Position: **Professor / Associate Dean**

Company/University: **INSETE**

1. Are you participating in any international technology transfer at the moment or have you been involved in the past?

☒ Yes

No

If yes, please explain involvement and whether your experience is from an industrial perspective or as an experienced researcher:

I am in charge of setting up INSETE's campus in Singapore and also managing the transition of the business from Fort Lauderdale to Singapore.

2. Do you believe that a pre-transfer questionnaire of this type should be used as part of a technology transfer process?

☒ Yes

No

Comments:

It seems to be an interesting tool for an analysis of the best practices for the technology transfer.

A PRE-TRANSFER ASSESSMENT FRAMEWORK FOR
INTERNATIONAL TECHNOLOGY TRANSFER

3. Did the pre-transfer assessment approach represent the way in which you undertake international technology transfer?

Yes

No

I am not sure

Comments:

I must raise questions about the technology itself. There is some reference to tacit knowledge which I would expand on that.

4. Did you have any difficulties understanding the approach?

☒ Not at all

☐ In some areas

☐ In most areas

Comments:

None

5. Did you have any difficulties completing the questionnaire?

☒ Not at all

☐ In some areas

☐ In most areas

Comments:

I seem to score at the more extreme ends of the scales. Do you need a scale from 1 to 10. Would 7 not be enough?

6. How long did it take you?

25 minutes

7. Do you believe that the pre-transfer assessment framework addresses the issues and problems which most multinational enterprises transferring technology face?

Please specify any areas of the framework that you believe to be correct:

I must raise some questions about the importance of the technology itself. So I said higher technology MNC's undertake as well as tacit knowledge

8. How would you like to see the framework (Figure 2) improved?

Please specify any areas of the framework that you would like to see developed further:

It includes you point on one way. The framework I have in technology exchange, or technology assessment during commercialization. This is a complex situation & not included here

A PRE-TRANSFER ASSESSMENT FRAMEWORK FOR
INTERNATIONAL TECHNOLOGY TRANSFER

9. Did you feel that the workbook covered all of the elements in sufficient detail?

I would suggest to look at the work of
Michael Gaudenzi (University) who specializes about
giving best practices. Some of it may be
interesting to you.

10. How would you like to see the workbook improved?

Please specify any areas of the questionnaire that you would like to see developed
further:

11. Any other comments?

Most of just all of your examples are out
the broad area of mechanical engineering. I
think that is (my suggestion). You need to include
a few examples of other technologies, systems, etc.

Thank you for your time and help. Your comments will be treated in confidence and
considered in the development of the final framework.

Best luck!



02-050 1999

Validation Sheet

Thank you for agreeing to participate in the validation of the pre-transfer questionnaire. Please complete the questionnaire booklet itself and then answer the validation sheet below.

Please return to:

Stephen Hobbs/
C/o Dr Jan Bennett
Department for Business Development
University of Plymouth
6th Floor, Moneycentre
Plymouth. PL 4 8AA

Feedback sheet completed by:

Name: *Wang Xing Ming*

Position: *professor*

Company/University: *Renmin University of China*

1. Are you participating in any international technology transfer at the moment or have you been involved in the past?

☒ Yes

☐ No

If yes, please explain involvement and whether your experience is from an industrial perspective or as an experienced researcher:

I have been involved international technology transfer in the past as an experienced researcher.

2. Do you believe that a pre-transfer questionnaire of this type should be used as part of a technology transfer process?

☒ Yes

☐ No

Comments:

From pre-transfer questionnaire of this type a lot of information can be collected for pre-transfer assessment.

A PRE-TRANSFER ASSESSMENT FRAMEWORK FOR
INTERNATIONAL TECHNOLOGY TRANSFER

3. Did the pre-transfer assessment approach represent the way in which you undertake international technology transfer?

☒ Yes ☐ No

Comments:

The indexes of pre-transfer assessment include technical, financial, social and environment protection assessment.

4. Did you have any difficulties understanding the approach?

☒ Not at all ☐ In some areas ☐ In most areas

Comments:

5. Did you have any difficulties completing the questionnaire?

☒ Not at all ☐ In some areas ☐ In most areas

Comments:

6. How long did it take you?

three hours

7. Do you believe that the pre-transfer assessment framework addresses the issues and problems which most multinational enterprises transferring technology face?

Please specify any areas of the framework that you believe to be incorrect:

yes.

8. How would you like to see the framework (Figure 2) improved?

Please specify any areas of the framework that you would like to see developed further:

In our assessment, we also consider government policy, infrastructure (not only communication links, but also power supply etc.) and relative law such as law of environment protection, law of resources protection etc.

A PRE-TRANSFER ASSESSMENT FRAMEWORK FOR
INTERNATIONAL TECHNOLOGY TRANSFER

9. Did you feel that the workbook covered all of the elements in sufficient detail?

10. How would you like to see the workbook improved?

Please specify any areas of the questionnaire that you would like to see developed further:

11. Any other comments?

Thank you for your time and help. Your comments will be treated in confidence and considered in the development of the final framework.

**A PRE-TRANSFER ASSESSMENT FRAMEWORK FOR
INTERNATIONAL TECHNOLOGY TRANSFER**

Validation Sheet

Thank you for agreeing to participate in the validation of the pre-transfer questionnaire. Please complete the questionnaire booklet itself and then answer the validation sheet below.

Please return to:

Stephen Hobbs/
C/o Dr Ian Bennett
Department for Business Development
University of Plymouth
6th Floor, Moneycentre
Plymouth, PL 4 8AA

Feedback sheet completed by:

Name: Robert Jensen

Position: Ph.D. Student

Company/University: Wharton

1. Are you participating in any international technology transfer at the moment or have you been involved in the past?

Yes ☒ No ☐

If yes, please explain involvement and whether your experience is from an industrial perspective or as an experienced researcher:

as an expert as researcher

2. Do you believe that a pre-transfer questionnaire of this type should be used as part of a technology transfer process?

Yes ☒ No ☐

Comments:

This could be useful if modified to allow for other types of knowledge or tech transfers. It could at least give a heads up as to possible problem areas.

A PRE-TRANSFER ASSESSMENT FRAMEWORK FOR
INTERNATIONAL TECHNOLOGY TRANSFER

3. Did the pre-transfer assessment approach represent the way in which you undertake international technology transfer?

Yes ☐

No ☒

Comments:

4. Did you have any difficulties understanding the approach?

Not at all ☐

In some areas ☒

In most areas ☐

Comments:

5. Did you have any difficulties completing the questionnaire?

Not at all ☐

In some areas ☒

In most areas ☐

Comments:

6. How long did it take you?

45 min

7. Do you believe that the pre-transfer assessment framework addresses the issues and problems which most multinational enterprises transferring technology face?

Please specify any areas of the framework that you believe to be incorrect:

see answer to Q 2

8. How would you like to see the framework (Figure 2) improved?

Please specify any areas of the framework that you would like to see developed

further:

The framework itself is not very parsimonious. Nor are all of the pieces well defined. I would opt for a smaller more operational model.

**A PRE-TRANSFER ASSESSMENT FRAMEWORK FOR
INTERNATIONAL TECHNOLOGY TRANSFER**

9. Did you feel that the workbook covered all of the elements in sufficient detail?

10. How would you like to see the workbook improved?

Please specify any areas of the questionnaire that you would like to see developed further:

See comments throughout the workbook.

11. Any other comments?

Thank you for your time and help. Your comments will be treated in confidence and considered in the development of the final framework.

A PRE-TRANSFER ASSESSMENT FRAMEWORK FOR
INTERNATIONAL TECHNOLOGY TRANSFER

Validation Sheet

Thank you for agreeing to participate in the validation of the pre-transfer questionnaire. Please complete the questionnaire booklet itself and then answer the validation sheet below.

Please return to:

Stephen Hobbs
Rital-CSM
Broadley Industrial Park
Belliver
Plymouth, UK.

PL6 7EZ

Feedback sheet completed by:

Name: GARY LANDRUM

Position: Program Manager.

Company/University: Compaq Computer.

1. Are you participating in any international technology transfer at the moment or have you been involved in the past?

Yes ☒ No ☐

If yes, please explain involvement and whether your experience is from an industrial perspective or as an experienced researcher:

I have had experience transferring designs of Marine Equipment from USA to Netherlands also much experience transferring designs & products of electronics to Taiwan - China from the USA and Between
2. Do you believe that a pre-transfer questionnaire of this type should be used as part of a technology transfer process? China etc

Yes ☒ No ☐

Comments: There is great need to understand existing capabilities between the home & host. Things as simple as being able to share file formats efficiently can be a great hindrance. Need to understand exactly what new technology is required to scope training

**A PRE-TRANSFER ASSESSMENT FRAMEWORK FOR
INTERNATIONAL TECHNOLOGY TRANSFER**

3. Did the pre-transfer assessment approach represent the way in which you would conduct international technology transfer?

Yes ☐ **YES + NO.** No ☐

Comments: we (company) go thru a tier assessment of potential partners. 1. a prescreening where we look at their business capabilities 2. an initial meeting 3. a full business team survey from multiple disciplines 4. you are allowed to skip

4. Did you have any difficulties understanding the approach?

Not at all ☒ In some areas ☐ In most areas ☐

Comments: it is very much ~~appropriate~~ a pragmatic and logical way to get detailed information about the host;

5. Did you have any difficulties completing the questionnaire?

Not at all ☒ In some areas ☐ In most areas ☐

Comments:

6. How long did it take you?

about 10 minutes *Needs to be the last question -*

7. Do you believe that the pre-transfer assessment framework addresses the issues and problems which most multinational enterprises transferring technology face?

Please specify any areas of the framework that you believe to be incorrect:

the key is you cannot have too much information on your proposed partner. Either a formal approach as proposed here or informal one that requires very knowledgeable ones on both sides.

8. How would you like to see the framework (Figure 2) improved?

Please specify any areas of the framework that you would like to see developed further:

~~How~~ we tend to require outside influences to put thesis requirements and structures in writing before moving forward - it really need to flow this looks more like a chase loop feed back system.

A PRE-TRANSFER ASSESSMENT FRAMEWORK FOR
INTERNATIONAL TECHNOLOGY TRANSFER

9. Did you feel that the workbook covered all of the elements in sufficient detail?

I have not had time to review it in great detail

10. How would you like to see the workbook improved?

Please specify any areas of the questionnaire that you would like to see developed further:

1 could be further generalized to include contract manufacturing external to the corp.

11. Any other comments?

I will have to send a separate doc. when I am not time crunched. This can work.

= If you put 2.3.2 in writing in the states they would sue your pants off!

Thank you for your time and help. Your comments will be treated in confidence and considered in the development of the final framework.

Validation Sheet

Thank you for agreeing to participate in the validation of the pre-transfer questionnaire. Please complete the questionnaire booklet itself and then answer the validation sheet below.

Please return to:

Stephen Hobbs
Rittal-CSM
Broadley Industrial Park
Belliver
Plymouth, UK.

PL6 7EZ

Feedback sheet completed by:

Name: John Sadlier

Position: Global Procurement Manager

Company/University: Dell Computer Corp

1. Are you participating in any international technology transfer at the moment or have you been involved in the past?

Yes ☐ No ☒ X

If yes, please explain involvement and whether your experience is from an industrial perspective or as an experienced researcher:

I will be involved in one shortly when Rittal transfer the manufacture of the 42U and 24U racks to their factory in the US.

2. Do you believe that a pre-transfer questionnaire of this type should be used as part of a technology transfer process?

Yes ☒ X No ☐

Comments:

**A PRE-TRANSFER ASSESSMENT FRAMEWORK FOR
INTERNATIONAL TECHNOLOGY TRANSFER**

I think the questionnaire is a little tedious but the final chart is a really good way of presenting the data.

3. Did the pre-transfer assessment approach represent the way in which you undertake international technology transfer?

Yes ☒ X No ☐

Comments:

It covered all the necessary steps. From dealing with Rittal for over 2 years I can clearly see that it is quite tailored to the Rittal situation. I would not transfer well to some companies.

4. Did you have any difficulties understanding the approach?

Not at all ☒ X In some areas ☐ In most areas ☐

Comments:

5. Did you have any difficulties completing the questionnaire?

Not at all ☒ X In some areas ☐ In most areas ☐

Comments:

6. How long did it take you?

35 minutes

10 minutes on the questionnaire and 25 minutes reading the workbook

7. Do you believe that the pre-transfer assessment framework addresses the issues and problems which most multinational enterprises transferring technology face?

Please specify any areas of the framework that you believe to be incorrect:

It does but it is very specific in dealing with issues that Rittal is exposed to
German – British and US cultural relations
Fabrication of large metal components.

8. How would you like to see the framework (Figure 2) improved?

Please specify any areas of the framework that you would like to see developed further:

No real issue here

9. Did you feel that the workbook covered all of the elements in sufficient detail?

Yes

10. How would you like to see the workbook improved?

Please specify any areas of the questionnaire that you would like to see developed further:

I have made comments above that it is tailored for Rittal. I am not sure if the intention of the workbook is specifically for Rittal or is it intended as a general document. If it is the latter then it needs to be widened a little.

The questions are a little tedious

11. Any other comments?

I think this is good work. If it is carried out then it will prevent problems that might otherwise arise.

Thank you for your time and help. Your comments will be treated in confidence and considered in the development of the final framework.

Appendix 3. Scored 'Degree of difficulty charts'

- 3.1. Mr Green
- 3.2. Mr Brittan
- 3.3. Prof. De Meyer
- 3.4. Prof. Wang
- 3.5. Mr Jensen

3. DEGREE OF DIFFICULTY CHART

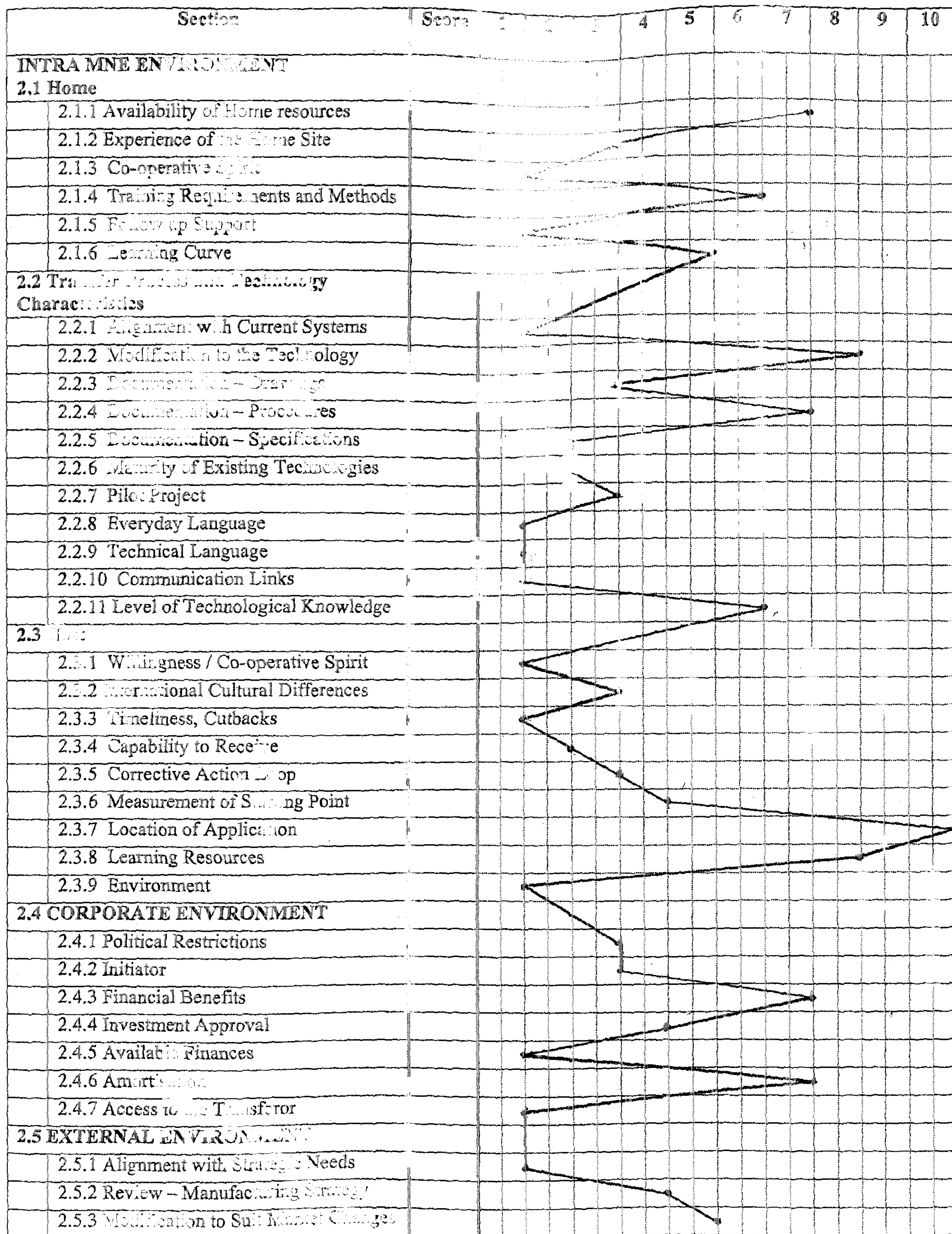


Figure 6 Pre-Transfer Assessment Framework – Chart

3. DEGREE OF DIFFICULTY CHART

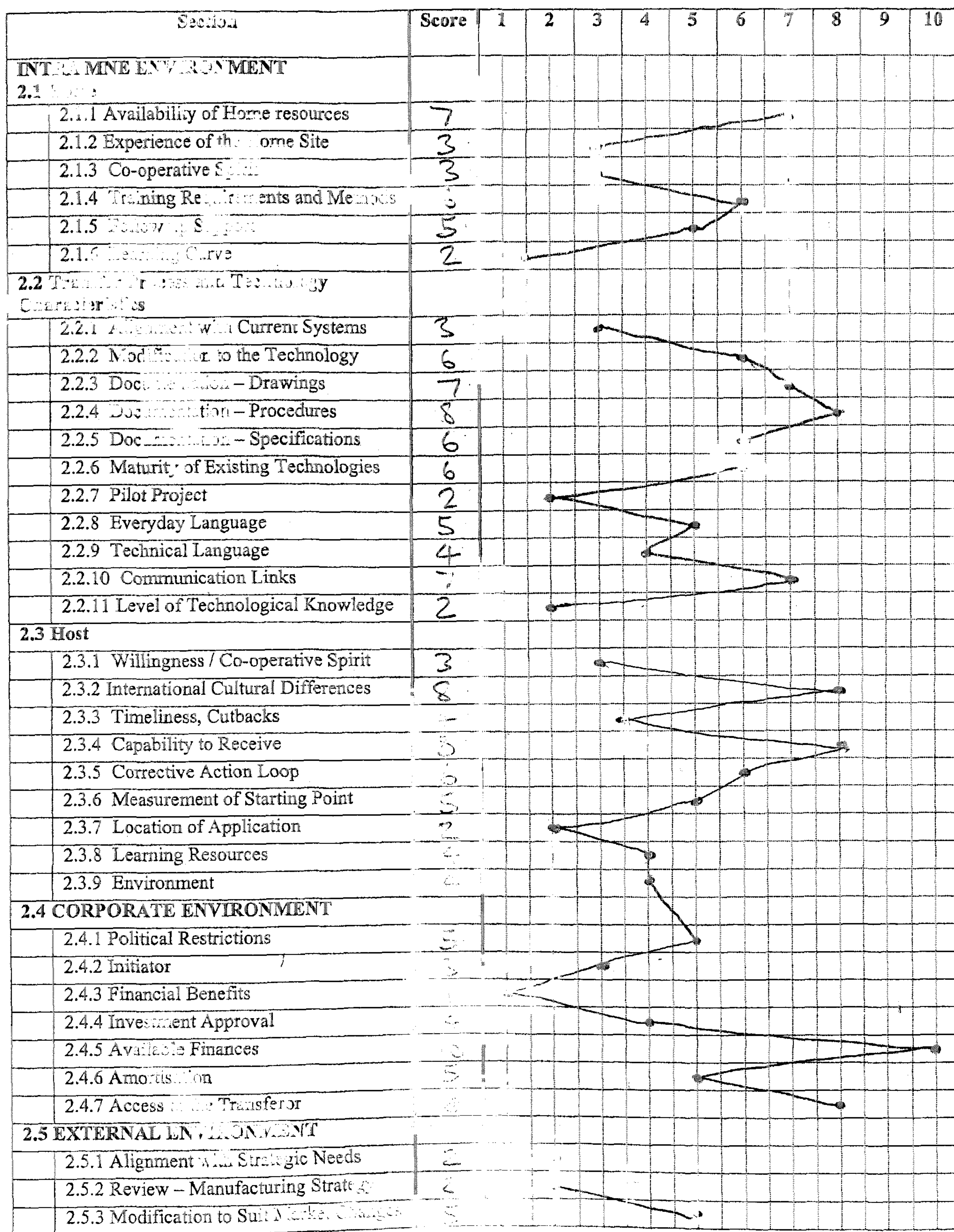


Figure 6 Pre-Transfer Assessment – Chart

3. DEGREE OF DIFFICULTY CHART

Section	Score	1	2	3	4	5	6	7	8	9	10
INTRA MNE ENVIRONMENT											
2.1 Home											
2.1.1 Availability of Home resources											
2.1.2 Experience of the Home Site											
2.1.3 Co-operative Spirit											
2.1.4 Training Requirements and Methods											
2.1.5 Follow up Support											
2.1.6 Learning Curve											
2.2 Transfer Process and Technology Characteristics											
2.2.1 Alignment with Current Systems											
2.2.2 Modification to the Technology											
2.2.3 Documentation – Drawings											
2.2.4 Documentation – Procedures											
2.2.5 Documentation – Specifications											
2.2.6 Maturity of Existing Technologies											
2.2.7 Pilot Project											
2.2.8 Everyday Language											
2.2.9 Technical Language											
2.2.10 Communication Links											
2.2.11 Level of Technological Knowledge											
2.3 Host											
2.3.1 Willingness / Co-operative Spirit											
2.3.2 International Cultural Differences											
2.3.3 Timeiness, Cutbacks											
2.3.4 Capacity to Receive											
2.3.5 Corrective Action Loop											
2.3.6 Measurement of Starting Point											
2.3.7 Location of Application											
2.3.8 Learning Resources											
2.3.9 Environment											
2.4 CORPORATE ENVIRONMENT											
2.4.1 Political Restrictions											
2.4.2 Initiator											
2.4.3 Financial Benefits											
2.4.4 Investment Approval											
2.4.5 Available Finances											
2.4.6 Amortization											
2.4.7 Access to the Transferor											
2.5 EXTERNAL ENVIRONMENT											
2.5.1 Alignment with Strategic Needs											
2.5.2 Review – Manufacturing Strategy											
2.5.3 Modification to Sub Market Changes											

Figure 6 Pre-Transfer Assessment Framework – Chart

I don't score always relevant
time. Perhaps the scale is too

3. DEGREE OF DIFFICULTY CHART

Section	Score	1	2	3	4	5	6	7	8	9	10
INTRALINE ENVIRONMENT											
2.1 Home											
2.1.1 Availability of Home resources											
2.1.2 Experience of the Home Site											
2.1.3 Co-operative Spirit											
2.1.4 Training Requirements and Methods											
2.1.5 Follow up Support											
2.1.6 Learning Curve											
2.2 Transfer of Knowledge and Technology Characteristics											
2.2.1 Alignment with Current Systems											
2.2.2 Modification to the Technology											
2.2.3 Documentation – Drawings											
2.2.4 Documentation – Procedures											
2.2.5 Documentation – Specifications											
2.2.6 Availability of Existing Technologies											
2.2.7 Pilot Project											
2.2.8 Everyday Language											
2.2.9 Technical Language											
2.2.10 Communication Links											
2.2.11 Level of Technological Knowledge											
2.3 Host											
2.3.1 Willingness / Co-operative Spirit											
2.3.2 International Cultural Differences											
2.3.3 Timeliness, Cutbacks											
2.3.4 Capacity to Receive											
2.3.5 Corrective Action Loop											
2.3.6 Measurement of Starting Point											
2.3.7 Location of Application											
2.3.8 Learning Resources											
2.3.9 Environment											
2.4 CORPORATE ENVIRONMENT											
2.4.1 Political Restrictions											
2.4.2 Initiator											
2.4.3 Financial Benefits											
2.4.4 Investment Approval											
2.4.5 Available Finances											
2.4.6 Amortisation											
2.4.7 Access to the Transferor											
2.5 EXTERNAL ENVIRONMENT											
2.5.1 Alignment with Strategic Needs											
2.5.2 Review – Manufacturing Strategy											
2.5.3 Modification to Suit Market Changes											

Figure 6 Pre-Transfer Assessment Framework – Chart

3. DEGREE OF DIFFICULTY CHART

*confusing
Logant - extend
with the
way down*

Section	Score	1	2	3	4	5	6	7	8	9	10
INTERMEDIATE ENVIRONMENT											
2.1 Home											
2.1.1 Availability of Home resources	2										
2.1.2 Experience of the Home Site	1										
2.1.3 Co-operative Spirit	1										
2.1.4 Training Requirements and Methods											
2.1.5 Follow up Support	3										
2.1.6 Learning Curve	3										
2.2 Transfer Process and Technology Characteristics											
2.2.1 Alignment with Current Systems	2										
2.2.2 Modification to the Technology	3										
2.2.3 Documentation – Drawings	3										
2.2.4 Documentation – Procedures	4										
2.2.5 Documentation – Specifications	4										
2.2.6 Maturity of Existing Technologies	3										
2.2.7 Pilot Project	4										
2.2.8 Everyday Language	4										
2.2.9 Technical Language	2										
2.2.10 Communication Links	2										
2.2.11 Level of Technological Knowledge	6										
2.3 Host											
2.3.1 Willingness / Co-operative Spirit	4										
2.3.2 International Cultural Differences	6										
2.3.3 Timeliness, Cutbacks	2										
2.3.4 Capability to Receive	5										
2.3.5 Corrective Action Loop	7										
2.3.6 Measurement of Starting Point	3										
2.3.7 Location of Application	7										
2.3.8 Learning Resources	5										
2.3.9 Environment	1										
2.4 CORPORATE ENVIRONMENT											
2.4.1 Political Restrictions											
2.4.2 Initiator	6										
2.4.3 Financial Benefits	1										
2.4.4 Investment Approval	3										
2.4.5 Available Finances	1										
2.4.6 Amortisation	2										
2.4.7 Access to the Transferor	4										
2.5 EXTERNAL ENVIRONMENT											
2.5.1 Alignment with Strategic Needs	2										
2.5.2 Review – Manufacturing Strategy											
2.5.3 Modification to Suit Market Changes	5										

Figure 6 Pre-Transfer Assessment Framework – Chart

Appendix 4. Case study notes - Alstom Power

This appendix details two of the interviewees who contributed to the research from the case study site at Rugby in Warwickshire.

1. Ian Maclean – Works Manager
2. Bill Armstrong – Business Unit Manager. Later promoted to Manufacturing and Plant Director

Both individuals contributed from different points, depending on their position in the company and exposure to technology transfer.

Mr Maclean's contribution was:

- Close relationship with senior people from other sites
- Good knowledge of operations on other sites
- Senior member of the international working parties
- First hand experiences of case studies

Mr Armstrong's contribution was:

- Senior position within the Ling Ao power station project – in depth knowledge.
- Detailed knowledge of the structuring and packaging of tacit knowledge: videos, photographs.
- > 10 years experience of transferring technologies between the Rugby site and customers, predominantly in China.

Both interviewees were known to the author and they were both prepared to discuss sensitive issues frankly where they would not normally do so outside their own company.

Basic outline of interview structure

1. Explanation of reason for the interview.
 - 1.1. Research into international technology transfer at Plymouth University.
 - 1.2. Background knowledge of the author about the company.
2. Discussion about the approach the interviewees company use to transfer technologies between sites.
 - 2.1. Formal procedures
 - 2.2. Methods of recording or transferring information/knowledge.
3. Examples of case studies.

Data collected from Mr Maclean

Introduction

The interview was opened with a brief discussion of physical and cultural changes since the authors last visit to Rugby. An outline of the research objectives and the technologies being investigated, were explained.

The general explanation of the technologies being considered was:

- Those which the company considered to be a ‘best practice’ at the Rugby site and could be transferred to one of the other manufacturing sites, that is the knowledge of how to do something better than the competition.
- How the company used off the shelf technologies in particular local ways which made their operation more effective.

Working parties

Mr Maclean started by explaining that the company promoted the sharing of good ideas.

He went on to explain that especially between the British and French staff managers spent

weekends with their opposite counterpart with the objective of presenting their best practices and learning from each other. This promoted good working relationships – improving trust, and setting an environment whereby passing ideas was not seen as arrogance and receiving good ideas was not seen as an inadequacy.

Mr Maclean went on to explain that the success of the transfers was almost exclusively down to the relationships and open-mindedness of the managers involved. He did however, say that some managers – particularly those with many years in the business and were perhaps a little distrusting were either not included in the programme or yielded few successful results.

Reject rotor

One of the experiences Mr Maclean recounted was that of the manufacture a rotor being transferred from one of the French sites to the site in Germany. The documentation was transferred with the material including drawings and planning sheets but due to language difficulties the coupling holes were drilled on the wrong PCD and the rotor was scrapped.

Authors note: An intermediate pressure rotor is a very high precision component, see figure 2, which is 1 of 5 rotors in a turbine train rotating at 3000rpm. Consequently, rectification of such errors is not a practical option in the industry.

Data collected from Mr Arnold (2008)

The interview commenced with a general discussion about the changes within the Rugby site, particularly about the influence of the French management style. The research objectives were explained to Mr Arnold in the same way that the background of the research was explained to Mr Maclean.

Ling Ao Power Station

One of the major projects Mr Armstrong had recently been involved in was the supply of the turbine generators for a power station build at Ling Ao in China.

As a condition of the contract being awarded to Alstom Power, 15% of the total build had to be manufactured in China, and Alstom Power were to provide the technical know-how of how to do it. The parts to be manufactured in China were all major sub-assemblies which the Rugby site had in depth experience.

Mr Armstrong explained that his main duty on this project was to manage the transfer process of the technical information. He was one of three engineers tasked with building the captured knowledge into a logical hierarchy which would enable the information to be retrieved in a useable way. Documentation included drawings, quality plans, work instructions and NC programmes. Additionally, to aid the transfer of processes more difficult to record in the form of traditional documentation, digital photographs and video recording was built into the records.

The software, specially developed for the project, was known internally as 'Information Transfer Software'. The use of this software to structure the information for easy retrieval was seen as a significant improvement over the previously manual recording of information.

Whenever contracts are awarded for the manufacture of a turbine generator in China, part of the contract is always to train a number of engineers from the power station. In the case of the Ling Ao contract, Mr Armstrong explained that due to the unusually high content of

local manufacture, there was an agreement to train the local engineers for a total of 160 man weeks. In addition, a number of expatriates were to be permanently employed in a problem solving capacity and the Rugby site were to provide on site experts to work for the duration of the manufacture.

Appendix 5 Case study interview notes— Nissan Motors UK.

This appendix details one of the interviews made at one of the case study sites. It does not report the interview verbatim. The conversations have been structured to aid the reader. However, where the author has believed that some explanation has been necessary, the author's comments appear in italic.

Basic outline of interview structure

4. Introduction of the author.
5. Explanation of reason for the interview.
 - 5.1. Research into international technology transfer at Plymouth University.
 - 5.2. Happy to steal ideas for use at Rittal
6. Approach the interviewees company use to transfer technologies between sites.
 - 6.1. Formal procedure
 - 6.2. Methods of recording or transferring information/knowledge.
7. Examples of case studies.

Background

Interviewee: Mr Doug Lorraine. Training Manager

Date: 4 May 2000

Location: NMUK. Sunderland UK

Prior to the interview, the author had written to Mr Lorraine and requested a meeting to discuss the experiences of NMUK when transferring technology between Nissan plants.

Introduction

The interview was opened by the author explaining the reason for the discussion: The author was undertaking a PhD research degree at Plymouth University investigating international technology transfer. Technologies of interest were explained to be those which would generically understood to be 'best practices'. Best practices of interest were explained to be either an application of an 'off the shelf' technology, such as Kanban or SMED, or a technology/practice that was developed within the Nissan group on one site, considered to be a good idea and then transferred to other sites.

Overall competitive strategies

Mr Lorraine started by explaining some of the overall strategic approaches of NMUK (it was during these discussions that many of the examples emerged and the detail pursued).

Mr Lorraine explained that within the automotive industry, business drivers had changed over the past 5 years or so. They had moved from a priority of:

1. Quality
2. Delivery
3. Cost
4. Management (The way the business is run including suppliers)

To:

1. Cost
2. Management
3. Quality
4. Delivery

He went on to explain that quality and delivery are simply expected to be achieved.
(Authors note: Through the discussions with Mr Lorraine, it seemed that the change in the priority of the business drivers was as a result of the merger with Renault where the European influence appears to be overriding the Japanese ethos.)

With the above in mind, he went on to explain that most improvement activities within the Nissan organisation were centred on reducing costs. This approach was taken to be so important that certain targets were given from the company's head office in Japan:

1. All manufacturing plants were to reduce costs by 30% over a 5 period.
2. The decision of which manufacturing site would produce the new 'Micra' model would be made based simply on price. That is, the Sunderland plant would have to compete on price against other sites within their own company.

Additionally, as part of the company reporting procedure, each site reports comparative measures. That is, measurements which compare all sites, enabling head office to see which sites are under performing. On a financial basis this is not unusual, however, within Nissan, personnel data (such as sickness) and overall equipment effectiveness (OEE) measurements are also compared.

Therefore, activities such as:

- Reducing set-up (or change-over) times.
- Reducing machine breakdowns.
- Optimising process up-time.
- Reduction of operator injury.
- Reduction of operator fatigue.

- Etc.

All help to keep the plant effective in the eyes of the headquarters and consequently more viable for the introduction of future models.

Advisors

Mr Lorraine explained that from the inauguration of the Sunderland plant in 1986, there have been 35 Japanese advisors on site. They normally stay for 1 to 2 years before returning back to Japan. The advisors each have an expertise in a particular field such as: financial reporting, design (within a particular field), quality engineering, IT, etc. Their jobs are not only to assist the management team at NMUK but to also feed back to Japan any developments and improvements which may help other sites.

Whilst the advisors do have an expertise in a specific field, they are not in a position to impose their advise. They suggest that a methodology or principle (technology) is adopted and even invite individuals to Japan to see the technology actually working. Additionally, the advisors are used to accumulate new technologies developed at the Sunderland plant and transfer them back to Japan. To use Mr Lorraine's words "It's 2 way traffic, they don't just bring it to us. They take our ideas back to Japan as well".

Managers/supervisors involved with the technology transfer.

Whilst discussing the differences between 'best practice' technology transfer and 'firm specific' technology transfer, Mr Lorraine made a point of explaining that at NMUK there were different levels of the management hierarchy involved in the two different types of technology. He suggested that best practices were normally transferred or developed by the local supervisors and that the firm specific technologies were normally transferred or developed by the management team.

the departmental managers. *(Authors note: This is probably due to the involvement of capital investment necessary when many of the firm specific technologies are introduced).*

Mr Lorraine believed that one of the main benefits for one of the managers or supervisors seeing the technology in Japan and transferring it back to NMUK is that it helps to sell the idea in a ‘not invented here’ environment. *(Authors note: He was clearly referring to the attitude of the workers and staff at the Sunderland plant).*

Technologies transferred between NMUK and Japan

Listed below are the examples of technologies transferred between NMUK and Japan. For a detailed description of the individual cases and issues therein please see section 4.4.4.

1. Moving shuttle for assembly of dash-board into car
2. Assembly line feeding by carousel
3. Standard operations
4. ‘ILU’ skill monitoring system
5. Plastic moulding of petrol tank in assembly line
6. Operator care programme
7. Water cooling of power press tooling

Appendix 6 Details of action research site visits

As part of the author’s duties to assist in the setting up and development of the Rittal Indian and American facilities, he visited both countries on a number of occasions. The very purpose of these visits was to transfer knowledge from the successful Rittal manufacturing plants to (i) the Bangalore (India) and Urbana (USA) sites which were new and being established, and (ii) the Springfield site which was some 10 years old but not really performing well.

This part of the author’s job provided excellent opportunity for action research into the technology transfer areas being investigated. Table A-1 below shows a record of the site visits to the plants described above.

		1996	1998	1999	2000
Month and place of visit		August – USA	February - India	February - USA	January - USA
			April - India	February - India	February - USA
			May - India	April - India	March - USA
			July - India	June - India	
			September - India	August - India	
			December - India	September - USA	
				October - India	
				December - India	

Table A-1 Record of action research site visits

Appendix 7. Glossary of terms

Definitions and terminology used by researchers and industrialists can often be non-uniform and there is frequently misunderstanding. Throughout this thesis the terminology used is that of the original author, to help clarify understanding, the following list is presented:

- **Home site** – The site sending the technology, sometimes referred to as the sender.
- **Host site** – The site receiving the technology, sometimes referred to as the recipient.
- **Just-In-Time** – A philosophy working towards manufacturing the right quantity of parts, to the right quality, just at the time their needed.
- **Kanban** – The Japanese word for card or signal. It is used to signal the requirement of a pre-determined quantity of components or materials. A kanban system is often used to ensure the availability of components/materials for a particular operation. It has the added benefit of enabling inventory checks easily and quickly.
- **Single Minute Exchange of Dies (SMED)** – An approach developed by Shigeo Shingo to reduce set-up times. Whilst it was originally targeted at changing large power press tools, the concept is now used to reduce set-up times in most activities, including assembly areas and office environments.

- **Technology** – A physically embodied or intangible knowledge about how to do something
- **Technology transfer** – The transfer of technology to a new application or new location.
- **Visual Factory** (Also known as Gemba Kanri) – An approach to sharing information throughout a factory. Boards are erected in suitable positions so that feedback is given to groups of workers regarding performance of the group (and company as a whole) against on-time delivery, customer complaints, quality standards, maintenance schedules, training programmes, future order book status, etc.

PUBLICATIONS

Published papers: Publications 1, 2 and 4 were international conferences at which the author was the presenter.

1. Hughes, D. R., Hobbs, S., and Larson, P., “Computer Aids To Distributed Decision Making In The Extended Enterprise” The International Conference On Improving Manufacturing Performance In A Distributed Enterprise: Advanced Systems And Tools, Edinburgh, Scotland, 13 & 14 July 1995.
2. Hobbs, S., and Hughes, D. R., “The Strategic Positioning Of World Class Manufacturing Techniques: The Multiplier Effect”. 28th International Symposium on Automotive Technology and Automation, Stuttgart Germany, 18 - 22 Sept. 1995.
3. Hobbs, S., and Hughes, D. R., “An Analysis Of The Logic Of The Design Of An Engineered Set-Up Reduction”, International Journal Of Engineering Applications 96(1), ISBN 0 94 8255 84 6.
4. Hobbs, S., Bennett, J. and Burns, R., “A Learning Curve Approach to Reducing the Cost of Technology Transfer in the Context of Multi-Site Manufacturing Operations”. European Operations Management Association – Workshop on International Operations, Aston Business School, 31 March 1998.